

EVENT LOGIC AND THE INTERPRETATION OF PLURALS

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by

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ABSTRACT

Simple sentences with plurals have interpretations that cannot be reduced to predications about individual objects. Such an interpretation for a sentence with n plurals cannot be represented by a logical form containing quantifiers over individuals that bind into an atomic n-adic predicate:

(i) $NP_1(x_1), \dots, NP(x_n) \quad V(x_1, \dots, x_n)$

(ii) Ten boys ate ten pies.

Chapter 1 introduces the classes of interpretations that cannot be so represented. An example is that interpretation of (ii) which is true in a situation where there are ten boys and ten pies, the boys eat the pies and no one boy eats more than part of any one of the pies. No individual boy ate any individual pie.

Chapter 2 on set-denotative logic presents the standard view according to which the non-reducibility of plurals is taken to show that the n plurals in (i) are quantifiers over sets of individuals that bind into an atomic n-adic predicate expressing a relation among sets of individuals.

Chapter 3 proposes event logic as an account of plural interpretations. Adding an argument position for events, it assumes a Davidsonian (1967) decomposition of the predicate into constituents expressing the role of each NP in an event of V-ing:

(iii) e 's eaters are ten boys & eat(e) & e 's eaten are ten pies

Quantifying over events in general replaces quantifying over sets. There are no atomic predicates expressing relations among sets of individuals.

An important feature of the event logic's syntax exploits the predicate's decomposition into constituents. It allows for restricted quantification, "[Q: A] B", in which one of the constituents occurring in, say, A is

separated from the remaining constituents and from the verb itself which are in B. Note that the set-denotative logic's atomic predicate does not allow a NP's semantic role to be separated from it. It appears with its full valence, providing a place for every argument in the relation it expresses.

Chapter 4 shows that a domain of quantification in the set-denotative logic cannot include all subsets of individual objects. If there is to be quantification over sets, it is restricted by a relationship to events.

Chapter 5 considers the extension of set-denotative logic that admits in the predicate a place for events while retaining the view that plurals are quantifiers over sets of individuals binding into atomic $n+1$ -adic predicates. The event logic, by quantifying over events, quantifies indirectly and in a restricted way over sets containing their participants. Chapter 5 shows that the extended set-denotative logic must be constrained to recover the relationship between sets and events derived in the event logic. A predicate in the extended set-denotative logic must not denote a set unless it is all the participants of an event, and the predicate must be about the set's activity only within a single event.

Chapter 6 argues for the syntax of event logic, showing that the constituents of the predicate's decomposition must sometimes be divided between the restriction and the matrix on which a quantifier operates.

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To My Parents

Max and Miriam
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Chapter 1

The interpretation of plurals

0. Several authors¹ have noted that various aspects of the interpretation of plurals, which will be introduced in this section, cannot be represented with standard logical forms. In analyzing plurals, set-denotative logic and event logic suggest different revisions of the standard view, which is, for this discussion, defined by the assumptions in paras. 0.1-0.3.

Let S be a simple sentence, as in (1), with n overt arguments NP_1, \dots, NP_n , none of which is expletive:

(1) $S [NP_1 VP [V \dots NP_n]]$

A logical form for S is such that:

0.1. V in S expresses an atomic relation in exactly n places. The polyadicity of the relation always corresponds to the number of NPs, and therefore variables bound by quantifiers occur only in NP positions.

0.2. A quantifier is a sentential operator. It operates on sentences in which the variables bound by the quantifier are replaced by elements in the

1. E.g., L. Carlson (1980), Cormack and Kempson (1981), Higginbotham (1980, 1984a), Hoeksema (1983), Jackendoff (1972), Kroch (1974), Lakoff (1972), Langendoen (1978), Link (1984), McCawley (1970), Scha (1981)

domain of quantification. The interpretation of any particular quantifier, when stated as a clause in a recursive definition of truth², conforms to the following schema:

- (2) " $Q\langle x_1, \dots, x_n \rangle \Phi\langle x_1, \dots, x_n \rangle$ " is true iff for Q -many c_1^i, \dots, c_n^i , $1 \leq i \leq k, \dots$
 $\Phi\langle c_1^1, \dots, c_n^1 \rangle$ is true...
 $\Phi\langle c_1^k, \dots, c_n^k \rangle$ is true...

The truth of the quantified sentence is determined by the quantifier from the truth of sentences of the form " $\Phi\langle c_1^i, \dots, c_n^i \rangle$." Each c_j^i is an element of the domain.

The schema in (2) includes within the standard view generalized quantifiers that are n -ary, " $Q\langle x_1, \dots, x_n \rangle$ " (see Higginbotham and May 1981). In later sections, several applications of n -ary quantifiers to the behavior of plurals are discussed³. An example of a binary quantifier will appear shortly in sec. 1.1.

We will also consider a standard view one that allows branching quantifiers. Branching quantifiers are not of great importance to anyone's⁴ theory of plurals, but they are included because the problems that plurals present for the standard view are not solved by branching quantification.

2. We are indifferent here to the semantical concept chosen, "truth", "truth in a model," etc. For simplicity, I avoid treating satisfaction by an assignment to free variables.

3. One type of n -ary quantifiers is proposed for plurals by Scha (1981) in his discussion of cumulative quantification and compound numerals, and the effects of n -ary quantifiers are reproduced by certain games in Carlson (1980) in which the plural rule has applied simultaneously to n plural NPs.

4. see note 1.

0.3. The value of a variable, i.e., each c_j^i in (2), is an individual, not a set or class. Because of the usage that the term "individual" is put to below, it would be better to say here that plural-marked predicates are not denoting expressions. On this standard assumption, it cannot be the case that the plural-marked predicate men(x) in "two men" is true of an entity that is men, and it cannot be the case that have left(x) in "they have left" is true of an entity that is them. Plurality is strictly part of the quantification. The only denoting expression in "two men" is the predicate man(x), true of an entity that is a man. The quantifier two-pl. requires that there be two such entities. Similarly, the only denoting expression in the VP of "they have left" is has left(x), which is true of the same kind of entity that man(x) is true of.

We turn now to those aspects of the interpretation of plurals which cannot be represented under the standard assumptions of para. 0.1-0.3.

1.1 The sum of plurals

Consider (3) and (4):

- (3) a. Ten boys ate ten pies
 - b. The boys ate the pies
 - c. They ate them
 - (4) a. Ten boys carried fifty cartons home
 - b. The boys carried the cartons home
 - c. They carried them home
- (from Carlson 1980)

The power afforded the standard view by n-ary quantifiers allows it to represent some but not all aspects of the interpretation of (3) and (4). We consider one particular reading, to be called the sum of plurals, which is

perhaps the most salient one for the sentences of (3) and (4). It is identified by two characteristics, one of which (see Jackendoff 1972 and Lakoff 1972) is that the plurals are independent: one is not within the scope of another. Sentence (3a) on this interpretation is about exactly ten boys and exactly ten pies. Suppose the NPs in each of these sentences are taken to form a binary quantifier:

- (5) a. [ten boys][ten pies]($\langle x, y \rangle$) x ate y
 b. [the boys][the pies]($\langle x, y \rangle$) x ate y
 c. [they][them]($\langle x, y \rangle$) x ate y
- (6) a. [ten boys][fifty cartons]($\langle x, y \rangle$) x carried y home
 b. [the boys][the cartons]($\langle x, y \rangle$) x carried y home
 c. [they][them]($\langle x, y \rangle$) x carried y home

The binary quantifier does represent the independence of its component plurals.

The second characteristic of a sum of plurals is that no particular mapping is imposed on the plurals. For (3), it is sufficient that they, the (ten) boys shared in the eating and that they, the (ten) pies were eaten. Similarly, it is enough for the truth of the sentences in (4) that they, the (ten) boys, participated in the carrying, and they, the (fifty) cartons, were carried home. Sentence (3a) is true of the particular situation in (7):

- (7)
$$\begin{array}{ccccc} b_1 \text{---} p_1 & b_2 \text{---} p_2 & b_3 \text{---} p_3 & b_4 \text{---} p_4 & b_5 \text{---} p_5 \\ b_6 \text{---} p_6 & b_7 \text{---} p_7 & b_8 \text{---} p_8 & b_9 \text{---} p_9 & b_{10} \text{---} p_{10} \end{array}$$

 where b_1 ate p_1 , ...and b_{10} ate p_{10} .

The binary quantifier only approximates this second characteristic of the sum of plurals. If the quantifier is consistent with the standard assumptions, this characteristic is not fully represented. The approximation is achieved if the binary quantifier is interpreted as in (8), an instance of

the schema (2).

(8) "[ten boys]X[ten pies]($\langle x, y \rangle$) $\Phi(x, y)$ " is true iff
for ten boys, b_1, \dots, b_{10} and for ten pies, p_1, \dots, p_{10} ,
" $\Phi(b_i, p_j)$ " is true for $1 \leq i \leq 10$.

Note that the sentences on the right-hand side of (8), " b_i ate p_j ", are true of the situation (7), where each b_i is a boy, and each p_j is a pie. If this collection of sentences is true, the binary quantification in (5a), interpreted according to (8), is true. Consistent with the standard assumption of para. 0.2 and 0.3, (8) treats the quantifier as an operator on sentences of the form " $\Phi(c_i, c_j)$ ", where c_i and c_j are individuals in the

5. As a serious statement of the interpretation of binary quantifiers, (8) conceals some problems. Note first that the analysis of binary quantification should not assign to (5a) an interpretation that can be paraphrased by "there are some ten boys who ate pies, and there are some ten pies eaten by boys." For any ten boys and ten pies, (5a) ought to be true of them just in case the boys ate the pies. But, the paraphrase is true of them even if the boys ate only other pies and the pies were eaten by only other boys. This problem is avoided by proposing an interpretation for the binary quantifier that is essentially paraphrased by "ten boys are all the boys eating pies, and ten pies are all the pies being eaten by boys." If this interpretation is true of some ten boys and some ten pies, then the boys must have eaten the pies. There are no other pies that the boys might have eaten, and no other boys that might have eaten the pies.

Scha (1981) in his remarks on cumulative quantification points out that the quantifiers of a sentence like (3a) can have the non-increasing ("ten and no more than ten") interpretation just paraphrased. But, the binary quantifier, if viable, must also provide an increasing interpretation—one that does not exclude other boys eating other pies—which is true of some boys and some pies only if they ate them. One possibility is to interpret the quantifiers relative to some context that fixes a subextension of the relation eat(x, y), for which an appropriate paraphrase is something like "ten boys are all the boys eating pies there, and ten pies are all the pies being eaten there." This does not inhibit what pie-eating goes on elsewhere.

The binary quantifier, if we have to talk about subextensions of the relation in interpreting it, is plainly set-theoretic. This however does not go beyond the intended scope of the standard view in para. 0.1-0.3. The predicates, such as "eat(x, y)", still do not denote sets. The values of the variables, the c_j in the schema (2) and the b_i and p_j in (8) are still individuals.

domain.

Within the standard assumptions (0.1-0.3), n-ary quantifiers are necessary for even the approximate representation of the sum of plurals. Lauri Carlson (1980) points out that if the plurals of the sentences in (3) and (4) are taken as unary quantifiers over individuals, an interpretation of, for example, (3a) that is true of (7) cannot be represented. The logical forms of (9), where the values of x and y are individuals, are inappropriate.

(9) sum of plurals, (3) and (4):
* (Q boys)x (Q pies)y [x ate y]
* (Q pies)y (Q boys)x [x ate y]
* (Q boys)x \ [x ate y]
 (Q pies)y /

Note in particular that although the branching quantification asserts that we are talking about exactly ten boys and exactly ten pies, it requires every one of the boys to have eaten every one of the pies.

Despite the power of n-ary quantifiers, the standard assumptions are too stringent for an exact representation of the sum of plurals, as the references of note 1 show. Consider situations that involve exactly as many boys, pies and cartons as the sentences of (3) and (4) require. Suppose that in the situations for (3), the boys eat the pies, but they pass them around. Similarly, suppose that in the situations for (4), the boys carry the boxes home, but they have also passed them around. The sum of plurals interpretation of these sentences remains true in these new situations, but the binary quantification in (5) and (6) has become false. Recall that for the binary quantification of (3a) to be true, there must be a collection of true sentences of the form "b_i ate p_i". Ten distinct boys and ten distinct

pies must be referred to in this collection. Because the pies were passed around, there is no such collection of true sentences. Each boy has eaten only part of any one pie. Similarly, the truth of the binary quantifications in (6) depend on collections of true sentences of the form "b_i carried c_j home". But, the passing around falsifies any such collection. Each boy has done some carrying, but none has carried a carton home.

The problem of this section, the sum of plurals, is summarized as follows. Although predicates such as carry(x,y) and eat(x,y) are predicable of individuals, once plurals are their arguments, they acquire interpretations that are not reducible within standard assumptions (0.1-0.3) to predications about individuals, even if this reduction is attempted with something as powerful as n-ary quantifiers.

1.2 Quantification with collective predicates

- (10) a. The unionists gather in the square
- b. Ten composers collaborated (with each other)
- (11) a. Few unionists gathered in the square
- b. Few composers collaborate (with each other)

Collective predicates, such as gather in the square and collaborate (with each other), are apparent exceptions to 0.3. They appear to denote sets of individuals, not being predicable of individuals:

- (12) * John gathered in the square
- * Gilbert collaborated (with each other)

These collective predicates also combine with quantifiers. The sentences in (10) and (11) have interpretations that appear to quantify over the sets

denoted by the predicate. Thus, (11a) has an interpretation that requires that few unionists be found in the union of all sets (of unionists) that gather in the square. Similarly, in (10a), the unionists that make the sentence true may be divided among distinct sets c_1, \dots, c_n each of which gathers in the square. This would suggest that there are variables for a domain sets, if, as in 0.2., quantifiers are operators.

1.3 Event-dependent quantification

- (13) a. Few experts (ever) agree
b. Few Democrats (ever) vote with the President
c. Few good students are (ever) unprepared
d. Few advanced students (ever) collaborated on three problems

L. Carlson has observed that the sentences in (13) have an interpretation, which I will call event-dependent quantification, in which the quantifier few N' seems to be within the scope of an (implicit) universal quantifier. The event-dependent interpretation of the quantifier in (13a) has the paraphrase "whenever there is an agreement, it involves few experts." Note that (13a) may be true with this interpretation although its interpretation according to para. 1.2. is false: if, for example, every one of many experts agrees with some other expert, but no one opinion is shared by many of the experts.

Chapter 2

Set-denotative logic

Set-denotative logic represents in a standardized form an analysis of plurals shared, more or less, by several authors who assume otherwise diverse frameworks⁶. Its basic assumption is that predicates denote sets, thus rejecting the standard assumption of para. 0.3. The standard assumptions about quantification in para. 0.1 and 0.2 remain⁷. Thus, there are variables whose values, c^i_j , in the schema in (2), are sets⁸. Some atomic sentences are shown on the left side of the biconditionals in (14). c_1 and

6. Carlson (1980), Cormack and Kempson (1981), Higginbotham (1980, 1984a), Link (1984), Scha (1981) among others.

Cormack and Kempson and Higginbotham do not treat decreasing quantifiers, and Cormack and Kempson do not treat quantification with collective predicates (1.2).

7. Higginbotham (1984a) appears to also deny para. 0.1. by assuming a place for events in the predicate bound by an existential quantifier. But, this assumption and the denial of para. 0.1 play no role in his analysis of plurals, which is essentially set-denotative. See chap. 3 on event logic, where rejecting para. 0.1 is crucial to the treatment of plurals.

8. The necessary domain of sets is the power set (minus the empty set) of those things that are individuals under para. 0.3. For example, the predicate men(y) denotes the members of the power set of men (minus the empty set). Every denotatum is a set of men (singletons included). The denotation does not include sets of...sets of men. Eberle (1970) shows that a domain of sets $D = \text{power set of } A \text{ minus the empty set}$ is isomorphic to the nominalistic domain of sums of members of A . The argument below against set-denotative logic, so called because sets are familiar, does not depend on any particular view of the aggregates denoted.

c_2 are sets.

- (14) "eat(c_1, c_2)" is true iff they, c_1 , eat them, c_2 .
"carry home(c_1, c_2)" is true iff they, c_1 , carry home them, c_2 .
"gather(c_1)" is true iff they, c_1 , gather.
"collaborate with (each other)(c_1)" is true iff they, c_1 , collaborate
(with each other).

In the logical syntax, predication involves only sets, not their member individuals⁹. The nonlogical meaning of a particular predicate specifies (by meaning postulate or otherwise) whatever behavior the member individuals must show for the predication of the set to be true.

We now introduce the clauses that interpret plural quantification in set-denotative logic. We then discuss the set-denotative representations of the phenomena described in chap. 1.

The first pair of clauses are for increasing quantifiers, such as some men, which do not imply an upper bound on the extension of the predicate. The second pair of clauses interpret non-increasing quantifiers, such as few men and exactly ten men, which do put an upper bound on the predicate. As first mentioned in note 5, Scha (1981) points out that some quantifiers, such as 600 Dutch firms and the Dutch firms, are in some contexts increasing and in others non-increasing. These may be interpreted by any of the following clauses^{10,11}.

9. We consider below a set-denotative logic that also contains variables sorted for individuals. Their presence at this point is not relevant.

10. (15) and (16) follow closely Carlson (1980) and Scha (1981), who are the most explicit in quantifying over sets.

11. A non-increasing quantifier establishes an upper bound on the extension of the predicate: Φ is true of C and no others. Hence, the clauses in (16) must take in everything that is Φ . Some of the non-increasing quantifiers,

(15) Increasing quantifiers.

a. (undivided reference to a denotatum¹²)

"[Q N'] $\Phi(x)$ " is true iff for some (class) c, c is [Q N']-many, and " $\Phi(c)$ " is true.

b. (divided reference to denotata)

"[Q N'] $\Phi(x)$ " is true iff for some (classes) c_1, \dots, c_k, \dots , the union of c_1, \dots, c_k, \dots is [Q N']-many, and " $\Phi(c_1)$ " is true...and " $\Phi(c_k)$ " is true....

(16) Non-increasing quantifiers.

a. (event-dependent)

"[Q N'] $\Phi(x)$ " is true iff every (class) c such that " $\Phi(c)$ " is true is [Q N']-many.

b. (non-event-dependent)

"[Q N'] $\Phi(x)$ " is true iff the union of all classes c such that " $\Phi(c)$ " is true is [Q N']-many.

2.1 The sum of plurals

In set-denotative logic, the sum of plurals interpretation of the sentences

those which are here called non-decreasing, establish at the same time a lower bound on the extension of the predicate, requiring at least some non-empty C to be Φ . Decreasing quantifiers allow the extension of the predicate to be empty. few critics and none of the books are examples of decreasing quantifiers, and exactly ten critics is a non-increasing, non-decreasing quantifier. Increasing quantifiers, as the existential quantification in (15) shows, establish a lower bound but impose no upper bound. Examples are ten critics, the boys and some books. (i) charts the terminology used here.

(i) NP is non-increasing if it establishes an upper bound

NP is increasing if it does not establish an upper bound

NP is non-decreasing if it establishes a lower bound

NP is decreasing if it does not establish a lower bound

No NP is both increasing and decreasing. In this work, "(non-)increasing" is the more important feature, as the classification imposed by (15) and (16) would indicate.

12. For convenience and without prejudice, I say "two men" in "two men left" refers to two men, although it is sometimes argued that a quantifier, being an operator rather than a name, has no reference. See Sommers (1982) and references cited there for discussion.

of (3) and (4) derives from (15a) applied to both quantifiers. An equivalent interpretation results from either assignment of scope to the quantifiers when both are interpreted by (15a).

- (3) a. Ten boys ate ten pies
- b. The boys ate the pies
- c. They ate them
- (4) a. Ten boys carried fifty cartons home
- b. The boys carried the cartons home
- c. They carried them home

The forms of (17) and (18) are not those interpreted by the clauses of (15) and (16), but they conveniently show the logical structure of the interpretations that result from clause (15a). Variables x , y , and z are for individuals, and variables r , s and t are for sets.

(17) a.,b.,c.:

[Er:boys(r)][Es:pies(s)] [[ten boys(x)]x \in r & [ten pies(y)]y \in s & eat(r,s)
 [Er:boys(r)][Es:pies(s)] [[the boys(x)]x \in r & [the pies(y)]y \in s & eat(r,s)
 [Er:boys(r)][Es:pies(s)] [[they(x)]x \in r & [them(y)]y \in s & eat(r,s)]

(18) a.,b.,c.,:

[Er:boys(r)][Es:cartons(s)][[ten boys(x)]x \in r & [ten cartons(y)]y \in s & carry(r,
 [Er:boys(r)][Es:cartons(s)][[the boys(x)]x \in r & [the cartons(y)]y \in s & carry(r,
 [Er:boys(r)][Es:cartons(s)][[they(x)]x \in r & [them(y)]y \in s & carry home(r,s)]

All the quantifiers of (3) and (4) are increasing and interpreted to have undivided reference to a denotatum ((15a)) Thus, any sentence of (3) is true if there is one true atomic sentence "eat(c_1, c_2)" where c_1 is an appropriate set of boys and c_2 is an appropriate set of pies. The atomic sentence is true according to the nonlogical meaning of the predicate. In particular, the situation described in para. 1.1 in which the member boys of c_1 pass around the member pies of c_2 does not falsify the atomic sentence in which eat(x,y) is predicated of c_1 and c_2 .

2.2 Quantification with collective predicates

The phenomena described in para. 1.2 are treated in set-denotative logic under clauses (15b) and (16b).

- (10) a. The unionists gather in the square
b. Ten composers collaborated (with each other)
- (11) a. Few unionists gathered in the square
b. Few composers collaborate (with each other)

If the increasing quantifier of (10a) is interpreted by clause (15b), its reference can be divided among distinct sets of gatherers. Similarly, the quantifier in (10b), if interpreted by (15b), can divide its reference among distinct sets of collaborators. If the non-increasing quantification in (11) is interpreted by clause (16b), it comprehends all sets (of unionists) that gather in (11a) and all sets (of composers) that collaborate in (11b). The resulting interpretations are equivalent, in the convenient notation seen first in (17) and (18), to the following sentences:

- (19) a. [The unionists(x)][Er:unionists(r)] $x \in r$ & gather in the square(r)
b. [The composers(x)][Er:composers(r)] $x \in r$ & collaborate (w/ e. o.)(r)
- (20) a. [Few unionists(x)][Er:unionists(r)] $x \in r$ & gather in the square(r)
b. [Few composers(x)][Er:composers(r)] $x \in r$ & collaborate (w/ e. o.)(r)

2.3 Event-dependent quantification

The interpretation of quantifiers, called event-dependent, which was discussed in para. 1.3, is derived in set-denotative logic from clause

(16b). The quantifier, under this clause, is the measure of each set denoted by the predicate. The event-dependent interpretation of the quantifiers in (13) is equivalent to (21):

- (13) a. Few experts (ever) agree
 b. Few Democrats (ever) vote with the President
 c. Few good students are (ever) unprepared
 d. Few advanced students (ever) collaborated on three problems
- (21) a. $[Ar:experts(r)] [agree(r) \rightarrow [Few\ experts(x)]x \in r]$
 b. $[Ar:Democrats(r)] [vote\ with\ the\ President(r) \rightarrow [Few\ good\ students(x)]x \in r]$
 c. $[Ar:good\ students(r)] [unprepared(r) \rightarrow [Few\ good\ students(x)]x \in r]$
 d. $[Ar:students(r)] [collaborate\ on\ three\ problems(r) \rightarrow [Few\ students(x)]x \in r]$

2.4

We conclude this description of set-denotative logic with two remarks.

2.4.1

In the standard logic of individuals, as was seen in sec. 0.1, an approximation of the sum of plurals was obtained by n-ary quantification. In the set-denotative logic, unary quantifiers were sufficient for the sum of plurals interpretation of the examples cited. We mention here two kinds of interpretations that require n-ary quantification within the set-denotative logic.

For the first kind, suppose there is a dyadic predicate on sets collaborate(x,y). Atomic sentences with this predicate meet the condition in (22):

- (22) "collaborate on $\langle c_1, c_2 \rangle$ " is true iff everyone of c_1 collaborated with everyone of c_1 on every one of c_2 .

Thus collaborate on(x,y)" can be predicated only of the participants of an intimate collaboration.

(23) These composers collaborated on those operas.

The sentence (23), which includes this predicate, is however true even if the composers and the operas are divided among separate collaborations.

In this situation, (23) would turn out false if, following the earlier examples of the sum of plurals, both the composers and the operas were interpreted by clause (15a) to have undivided reference to a denotatum. The composers are not a single set of individuals who all together collaborated, and the operas are not a single set whose members were all collaborated on by the composers. The reference of the quantifiers, these composers and those operas must be divided by the application of clause (15b). At this point, we can show the failure of unary quantification to assign the correct interpretation to (23).

Suppose that these composers has wide scope and is thus the first of the two unary quantifiers to be interpreted by (15b). Then, the composers are divided among sets c_1, \dots, c_k such that the sentences "collaborate on (c_i , those operas)" for $1 \leq i \leq k$ are true. This interpretation is already inappropriate for the situation described, because it requires every opera to be part of the work of at least k separate collaborations. Each of the k sets, c_1, \dots, c_k , is related to all the operas by the one of the sentences "collaborate(c_i , those operas)", $1 \leq i \leq k$. In each of the k -many sentences, (15b) will apply to those operas. For the subject c_i of each of these sentences, (15b) may divide the operas among several of c_i 's collaborations;

but, note that every opera must appear in at least one of the collaborations of each of the k sets of composers. But, the truth conditions for (23) are weaker. If the composers are divided among k separate sets of collaborators, it is sufficient for the truth of (23) that every opera be the work of just one of these sets. Of course, the opposite assignment of scope, first applying (15b) to those operas and then to these composers, also ascribes truth conditions to (23) that are too strong.

The correct conditions are ascribed to (23) if these composers and those operas are interpreted as a single binary quantifier over ordered pairs of sets (cf. (8) above.):

(24) "[these composers] \times [those operas]($\langle x, y \rangle$) collaborate on(x, y)" is true iff for sets c_1, \dots, c_k the union of which is these composers and for sets o_1, \dots, o_k the union of which is these operas, "collaborate on(c_1, o_1)" is true, ... and "collaborate on(c_k, o_k)" is true.

The need for n -ary quantification depends on the assumption that (23), which is true even if the composers and the operas are divided among separate collaborations, contains a predicate with the truth conditions described in (22). But, this is something we cannot be sure of. The meaning of the predicate in (23) may itself require less intimate collaboration than (22):

(25) "collaborate on(c_1, c_2)" is true iff everyone in c_1 collaborated with someone in c_1 on some one of c_2 , and every one of c_2 was collaborated on by members of c_1 .

If (25) is the predicate in (23), then the sentence is like the other examples of a sum of plurals. The plurals are unary quantifiers. Under clause (15a), these composers has undivided reference to a denotatum c_1 , and those operas refers to a denotatum c_2 . (23) will then be true of the composers and the operas, divided among separate collaborations, without

n-ary quantification. At this point, I know of no evidence that suggests whether the weak truth conditions of (23) should derive from the lexicon ((25)) or from the apparatus of quantification theory.

The second kind of interpretation that requires n-ary quantification is called by Scha (1981) cumulative quantification.

(26) 500 Dutch firms bought 600 American computers. (from Scha 1981)

(26), when so interpreted, is true just in case the relation "x, a Dutch firm, buys, y an American computer" involves exclusively five hundred Dutch firms and six hundred American computers. No other Dutch firm bought an American computer, and no other American computer was bought by a Dutch firm.

Cumulative quantification is thus non-increasing. Unlike the first kind of interpretation, there is no doubt that cumulative quantification must be n-ary.

In para. 2.1, the sum of plurals is the interpretation that results from a predication of individual sets. By clause (15a), the plurals in (3a) refer to a set of ten boys and a set of ten pies, of which eat(x,y) is predicated. The quantifiers are increasing.

(3) a. Ten boys ate ten pies

The plurals of (26) so treated would not yield cumulative quantification. Predicating buy(x,y) of a set of five hundred Dutch firms and a set of six hundred computers is not exclusive. Other Dutch firms may have bought other American computers.

Quantifiers under clause (16b) are non-increasing as required. But, cumulative quantification is not derived if the quantifiers of (26) are unary

and interpreted consecutively under some assignment of scope. Consider the interpretation under (16b) of the scope assignment in (27):

(27) 500 Dutch firms-x 600 American computers-y bought(x,y)

(27) says that there are exactly five hundred Dutch firms that can be divided among sets each of which bought exactly six hundred American computers. This is not the cumulative interpretation of the quantifiers in (26), according to which six hundred is the total number of American computers bought by all Dutch firms. (27) has more in common with the cumulative quantification of (28):

(28) Exactly 500 Dutch firms bought at least 600 American computers

They can both be true in situations where more than six hundred American computers are bought by Dutch firms.¹³ Similar observations show that the alternative assignment of scope to the quantifiers of (26) will not represent cumulative quantification.

Scha's (1981) compound numerals are non-increasing n-ary quantifiers over sets. The cumulative quantification in (26) requires a binary quantifier that meets the condition in (29):

(29) "[500 Dutch firms][600 American computers]($\langle x,y \rangle$) buy(x,y)" is true iff exactly 500 Dutch firms can be divided among sets f_1, \dots, f_k and exactly 600 American computers can be divided among sets c_1, \dots, c_k such that "buy(f_1, c_1)" is true, ... and "buy(f_k, c_k)" is true.

13. (27) entails (28). It is also entailed by (28) if buy(x,y), predicated of two sets, is reducible to the relation among their members described in (i):

(i) "buy(c_1, c_2)" is true iff every member of c_1 bought some member of c_2 , and every member of c_2 was bought by some member of c_1 .

2.4.2

The last remark is to eliminate a possible confusion about the terminology used here. Predicates and atomic predicates are relative to a given system of quantification. A predicate is whatever is operated on by quantifiers. An atomic predicate is a predicate that contains no quantifiers. They are what the system of quantification, a list of recursive definitions (e.g., (15) and (16); v. (2)), leaves unanalyzed. On most occasions, we will let the verb itself stand for the atomic predicate of its sentence. In discussing the quantificational structure of, for example, "few unionists gather", we let "gather(x)" stand for the atomic predicate and for whatever the quantifier "few unionists" operates on according to (16). Similarly, in the sentence "the sides of rectangle 1 cross the sides of rectangle 2", we let "cross(x,y)" stand for the atomic predicate left after the analysis of the quantifiers "the sides of rectangle 1" and "the sides of rectangle 2". But this convenience is not meant to exclude the possibility that what is atomic for the system of quantification is still complex. The meaning of the first atomic predicate may be better represented by "unionists-gather(x)", true only of sets of unionists that gather. Instead of the paraphrase "any gathering contains few unionists", the event-dependent interpretation of that sentence comes out as "any unionist-gathering contains few unionists", and the non-event-dependent interpretation is "few unionists were in any unionist-gathering" rather than "few unionists were in any gathering." Similarly, the atomic predicate of the second example may be one that can be true of a pair of sets x and y just in case they are each a set of rectangle sides, "sides of rectangle cross sides of rectangle(x,y)".

The purpose of this remark is just to point out that the differences in interpretation wrought by varying the internal structure of the atomic predicates will not affect the force of the arguments developed here. In the body of the text, I will assume, despite the formalism, that the atomic predicates are complex, "unionists-gather(x)" and "sides of rectangle cross sides of rectangle(x,y)". This is likely to be the correct assumption for at least the reason pointed out in Scha(1981), namely, that the nonlogical meaning of a predicate depends on the nominals it is construed with, as illustrated by his example, "sides of rectangle cross sides of rectangle(x,y)", which may have a meaning, such as the one discussed in the following section, that is distinct from other predicates based on "cross", even from a predicate as similar as "lines cross lines(x,y)". Moreover, we will see in sec. 3.1 that the event logic must assume that atomic predicates are similarly complex in order to derive Scha's cumulative quantification discussed in sec. 2.4.1.

Whether or not atomic predicates are correctly considered to be complex, I will assume it in discussing the set-denotative logic just to put it in the best possible position with respect to the arguments developed below, especially in chapter 4. Where necessary, I will indicate in footnotes how to modify the argument in order to accommodate simple atomic predicates; but, it will be seen that the defects in set-denotative logic are thereby exaggerated.

Chapter 3

Event logic¹⁴

The behavior of plurals is explained in terms of quantification over events. A crucial problem in their behavior was summarized at the end of para. 1.1 as follows: although predicates such as carry(x,y) and eat(x,y) are predicable of individuals, once plurals are their arguments, they acquire interpretations that are not reducible within standard assumptions (0.1-0.3) to predications about individuals. The approach of set-denotative logic is to reject the standard assumption 0.3 by having predicates denote sets. The approach of event logic to this crucial problem develops from the rejection of standard assumption 0.1.. In addition to the NP arguments, the logical form of any sentence in event logic contains a place for events. Quantifying over events replaces quantifying over sets of individuals.

The ontological commitment to events is discussed in more detail in sec. 3.4. Here we will introduce just enough about events in order to develop the logical syntax of plurals in sec. 3.0-3.3.

Event logic is committed to the existence of events as individuals in the world (or, as elements in the domain). An event is not as solid as a table,

14. see Davidson 1967; Kroch 1974, p. 257ff.

but it has as much concrete reality as, say, a baseball game. We talk about events, individuate them, and refer to them directly, as in that was a fine baseball game. What can be said about events reveals that they can have internal structure. Thus, the predicate is a baseball game(x) denotes individuals which contain, according to the rules of the game, opposing teams and players in prescribed roles executing various actions. The roles and actions that are taken to constitute an event of this kind are a matter of definition or, in this case, invention, and the concept of a baseball game may be so precisely articulated that some of its constituent roles and actions do not exist outside the game. However ad hoc they are, one knows that whatever is a baseball game has these roles and actions fulfilled:

(30) That_i was a fine baseball game,
it_i's pitchers were Neil Briskman and Ed Himmelfarb, and it_i's
catchers were David Eisenberg and Jerry Silverman.

Because of our knowledge of baseball, we know that Briskman and Himmelfarb threw balls, and Eisenberg and Silverman caught balls. We also know, because that_i and the two occurrences of it_i refer to the same baseball game, that Briskman and Himmelfarb threw balls to Eisenberg and Silverman. Note that (30) does not contain a dyadic predicate to express this relation between the pitchers and the catchers, rather the knowledge of this relation is conveyed indirectly through what we know about the event in which they all participated.

This use of events to mediate the expression of relations is the main "trick" behind event logic and our analysis of plurals. Thus a sentence such as (31) has an interpretation according to which there was an event which was

a selling, it involved three agents as sellers, it involved twenty-five buildings as what was sold, and it involved two investors as sellees.

(31) Three agents sold twenty-five buildings to two investors.

(32) Ee [e was a selling & e's sellers were three agents & e's sellees were two investors & e's sold were twenty-five buildings.]

The fact that the three agent's selling was of the twenty-five buildings and to the two investors is known from the participation of agents, buildings and investors in the same event.

We now show by example how the non-reducibility of plurals to singulars is treated in event logic. Event logic tries to treat the three aspects of plurals (1.1.-1.3.) which cannot be represented within the standard assumptions (0.1.-0.3.) by quantifying over events. Comparison with set-denotative logic will bring out an important syntactic difference related to the "trick" with mediating events. Events are like sets in "containing" participants. With respect to this similarity, the variable over events is the only place in the event logic for quantifying over set-like objects. In the event logic, there are no atomic relations with two or more places whose arguments are set-like objects. But, in set-denotative logic, every plural occupies such a place.

Within the standard assumptions 0.1-0.3, the sentence in (33) plainly cannot be reduced, according to the quantification schema 0.2, to sentences about individual points:

(33) The points are densely ordered

In set-denotative logic, is densely ordered(r) denotes sets, and the points refers to one set of which the property is predicated:

(34) [Er: the points(r)] is densely ordered(r)¹⁵

We can assume, for concreteness, that the predicate, monadic in set-denotative logic, meets the condition in (35), which prescribes the familiar axioms of a dense order. The values of r are arbitrary sets of points¹⁶:

(35) Let "AxDO" abbreviate:

Ex Ey ($x \in r$ & $y \in r$ & $x \neq y$) &
(x) ($x \in r \rightarrow \neg x < x$) &
(x)(y)(z) (($x \in r$ & $y \in r$ & $z \in r$) \rightarrow (($x < y$ & $y < z$) \rightarrow $x < z$)) &
(x)(y) (($x \in r$ & $y \in r$) \rightarrow (($\neg x < y$ & $\neg y < x$) \rightarrow $x = y$)) &
(x)(y) (($x \in r$ & $y \in r$) \rightarrow ($x < y \rightarrow$ Ez ($z \in r$ & $x < z$ & $z < y$)))

"is densely ordered(r)" is true iff AxDO

In the event logic for sentence (33), no change in (35) is required when sets of individuals are replaced by events. Instead of arbitrary sets of points, the values of r are events. According to (35), if r is an event of dense ordering, it contains participants, the points, that are densely ordered. Sentence (33) in the event logic can be paraphrased by "the points are involved in some dense ordering," which at this point is appropriately rendered by either of the forms in (36), their differences being immaterial at this point.

- (36) a. Er [r's participants are the points & is densely ordered(r)]
b. Er the points- x [x is one of r 's participants & is densely ordered(r)]

In (36b), the points is treated as a quantifier over individuals x . Hence there is a predicate on individuals x , " x is one of r 's participants". In

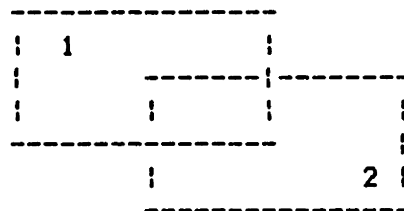
15. cf. (17) and (18).

16. I fix the meaning of is densely ordered(r) in some way in order to compare the set-denotative logic and the event logic; but, (35) is presented without commitment to the view that lexical meaning is represented with meaning postulates.

(36a), the NP the points is a predicate, similar to its use in (34) as a restriction on the quantifier, that denotes values of \underline{p} . The first (36a) is the one finally adopted for reasons discussed in sec. 3.1.1.

It would appear from a comparison of (34) with especially (36a) that replacing sets of individuals with events has few visible effects; but, this appearance is limited to sentences with only one NP argument. An important difference between set-denotative logic and event logic exists in the treatment of sentences with more than one NP argument. The example sentence (37) is from Scha (1981). As he points out, the interpretation of (37) that is true of the figure shown is again plainly not reducible within the standard assumptions to sentences about individuals.

(37) The sides of rectangle 1 cross the sides of rectangle 2



In the set-denotative analysis of (37), cross(x,y) (or, sides of rectangle cross sides of rectangle(x,y), see para. 2.4.2.) is a predicate that denotes pairs of sets of individuals:

(38) [Er:the sides of rectangle 1(r)] [Es:the sides of rectangle 2(s)] cross(r,s)

For arbitrary sets c_1 and c_2 , the predicate is true of them according to the condition in (39):

(39) "cross(c_1, c_2)" (or, "sides of rectangle-cross-sides of rectangle(c_1, c_2)") is true iff the members of c_1 are the sides of some rectangle, and the members of c_2 are the sides of some rectangle, and some member of c_1 crosses some member of c_2 .

The event-logical analysis of (37) quantifies over events that are crossings of sides of rectangles by sides of rectangles. Such an event e meets the condition in (40), which should be compared with (39):

(40) "cross(e)" (or, "sides of rectangle-cross-sides of rectangle(e)") is true iff e involves the sides of some rectangle, R_1 , and e involves the sides of some rectangle R_2 , and some side of R_1 crosses some side of R_2 .

Instead of (38), (37) has the alternative analyses (cf.(36)) in (41):

- (41) a. $\exists e$ [e 's crossers are the sides of rectangle 1 & cross(e) & e 's crossed are the sides of rectangle 2(e)]
- b. $\exists e$ [[the sides of rectangle1(x)] x is a crosser in e & cross(e) & [the sides of rectangle2(y)] y is crossed in e]

Recall that events are objects with internal structure. The meaning of "cross" (or, "sides of rectangle-cross-sides of rectangle") in (40) identifies what structure an event must have if it is an event of crossing. According to (41), some event of crossing involves the sides of rectangle 1 (as the crossers) and the sides of rectangle 2 (as the crossed).

The formal difference between event logic and set-denotative logic is apparent in (38) and (41) now that there are two plurals. The set-denotative expression (38) contains an atomic relation between sets, "cross(r,s)". In the event-logical (41), events are the only set-like objects, and there are no atomic relations among these. In set-denotative logic, following standard assumption 0.1., there is always a polyadic atomic relation among as many sets as there are plural NPs. Because of the "trick" of event logic, its atomic predicates have a place for only one set-like object, the event, whatever the number of arguments in the sentence.

3.0. We turn now to a system of logical forms that treats those aspects of

plurals (1.1-1.3) which cannot be represented within the standard assumptions (0.1-0.3). We show first how the three aspects of plurals are to be treated before proceeding to a more systematic description of event logic in sec.

3.1.

3.0.1. The sum of plurals.

- (3) a. Ten boys ate ten pies
 - b. The boys ate the pies
 - c. They ate them
 - (4) a. Ten boys carried fifty cartons home
 - b. The boys carried the cartons home
 - c. They carried them home
- (from Carlson 1980)

We have seen a sum of plurals represented in (41). The sum of plurals interpretation for (3a) is represented in (42):

- (42) Ee [e's eaters are ten boys & eat(e) & e's eaten are ten pies]

As required, neither plural is in the scope of the other, and nothing is said about which boy ate which pie.

3.0.2. Event-dependent quantifiers.

- (13) a. Few experts (ever) agree
- b. Few Democrats (ever) vote with the President
- c. Few good students are (ever) unprepared
- d. Few advanced students (ever) collaborated on three problems

(43) and (44) express the event-dependent interpretation of the quantifiers in (13a) and (13d), respectively:

- (43) Ae [agree(e) → e's agreeers are few experts]
- (44) Ae[[collaborate-on(e) & e's collaborated-on are 3 problems(e) &]
 → e's collaborators are few advanced students(e)]

The essential difference between the interpretations of 3.0.1 and 3.0.2 is that an existential quantifier binds the event variable in the sum of plurals, but in event-dependent quantification, the event variable is bound

by a universal or generic quantifier. (42) and (43)-(44) can be viewed as translating restricted quantifiers over events:

(45) [Ee: eat(e) & e's eaten are ten pies] e's eaters are ten boys

(46) [Ae: agree(e)] e's agreeers are few experts

(47) [Ae: collaborate-on(e) & e's collaborated-on are three problems(e)]
e's collaborators are few advanced students(e)

The logical forms adopted have a transparent correspondence to syntactic structure: the VP is a restriction on the quantifier over events. Thus, (48) and (49) are the logical forms for the sum of plurals and for event-dependent quantifiers, respectively.

(48) [Ee: VP(e)] INFL(e, NP)

(49) [Ae: VP(e)] INFL(e, NP)

3.0.3. Quantification with collective predicates

- (10) a. The unionists gather in the square
b. Ten composers collaborated (with each other)

- (11) a. Few unionists gathered in the square
b. Few composers collaborate (with each other)

(50) [The x: unionists(x)] gather in the square'(x)

(51) [Few x: composer (x)] collaborate'(x)

The sort of individual quantified over is determined by the subject quantifier. As we have seen in sec. 3.0.1 and 3.0.2, when the VP restricts the subject quantifier, the quantification is over individual events, and the NP is part of a predicate true of an event just in case the event's participants are exactly NP. When an NP is the subject quantifier, the quantification is over individual objects, and now VP must be a predicate on individual objects. Following Kroch (1974), a collective predicate becomes a predicate on individual objects "VP'(x)" so that:

(52) "VP'(c)" is true iff for some event e_i , c is involved in e_i and "VP(e)" is true

Thus, in the system to which (50a) and (51a) belong, a VP that denotes events when it is a subject will denote the participants of such events when it is a predicate.

3.1

Recall that the main "trick" of event logic uses events to mediate the expression of relations. Thus, the interpretation of (31) in (32) consists of statements about an event of selling.

(31) Three agents sold twenty-five buildings to two investors.

(32) Ee [e was a selling & e's sellers were three agents & e's sellees were two investors & e's sold were twenty-five buildings.]

As we have assumed, every event concept, such as the one predicated of e in "e is a selling", defines the internal structure of its denoted events: actions must be executed or states fulfilled by participants in various roles. What is represented by the syntactic structure of (31) is shown in (53). Syntactic structure associates the expressions of particular roles with particular NPs.

(53) $_S$ [seller(e, 3 agents) $_P$ [sell(e) sold(e, 25 bldgs) sellee(e, 2 investors)]]

We are essentially identifying theta roles (Chomsky 1981) with elements in Davidson's decomposition of predicates, and so a theta role always has a place for events. We will adopt a notation that is more transparent from the point of view of the syntax, in which prepositions stand for theta roles. Hence, instead of (53), we have (54):

(54) $S[INFL(e, 3 \text{ agents}) VP[sell(e) OF(e, 25 \text{ buildings}) to(e, 2 \text{ investors})]]$

The general schema is in (55), where $INFL, P_2, \dots, P_n$ stand for expressions for theta roles, and V stands for the expression of the event concept itself:

(55) $S[INFL(e, NP_1) VP[V(e) P_2(e, NP_2) P_n(e, NP_n)]]$

What follows is divided between rules deriving the logical forms for syntactic structures such as (55) and clauses in the form of truth definitions that indicate how the logical forms are interpreted. Some technical aspects of the system are proposed with great reluctance but for the sake of concreteness, including the decision to suppress in the representation of logical form some meaning differences that are introduced only in the interpreting clauses. Later remarks will point out what I consider to be the important properties of this system (see in particular sec. 3.2.), and it should be apparent in the arguments of the following chapters which aspects are crucial and which can be eliminated in alternative formulations.

We will assume that there is just one event variable e , thus avoiding syntactic structures in which the theta roles have distinct event variables¹⁷:

(56) $S[INFL(e_i, NP_1) VP[V(e_j) P_2(e_k, NP_2) P_n(e_l, NP_n)]]$

In deriving logical forms for syntactic structures, we also assume that well-formed logical forms contain no free variables. In particular, event variables free in syntactic structures, as in (55) must come within the scope

17. This assumption is quite natural. It means that syntactic structure arranges a number of predicates that each have a place for events-- just a simple gap, to be filled by the derivation of a logical form.

of a quantifier over events.

The logical forms for (55) correspond to various ways of binding the event variables. This will include the logical forms of simple scope relations among NP quantifiers, as in "two detectives each solved two crimes." These quantifiers over individual objects turn out to be complex, " $Q\langle x, e \rangle$ ", quantifying simultaneously over individual events. Our use of complex quantifiers is justified in sec. 3.3., where it is shown that if one assumes, as we have, a Davidsonian decomposition of the predicate, complex quantifiers are needed to avoid anomalous interpretations.

The logical forms for (55) are obtained by quantifier raising (see May 1977): some phrase, an NP or VP, is taken to be a restricted quantifier, A in (57), and the remainder of the sentence corresponds to the predicate term B ¹⁸:

(57) $A \cdot [Q\alpha A\alpha: \dots(\alpha)] B(\alpha)$

The three aspects of plurals (1.1-1.3) correspond to resulting logical forms, as in (59):

18. The subject-object asymmetry implied in raising the VP and no other phrases that include the verb is treated in Schein(in progress). See also Schein (1984) for some discussion.

For the purposes of this work, we could just as well assume that in forming a quantifier over events in (58) (cf. (59a) and (59b) in the text below) any theta roles and their NPs may belong to the restriction on the event quantifier.

(58) $_{\alpha} [Qe V(e): R_i(e, NP_i) \dots R_j(e, NP_j)] S(e, NP)$

There is then a separate question, which I take up elsewhere (in progress), about what constraints syntactic structure imposes on the identity of α in (58) and the choice of theta roles R_i, \dots, R_j and S .

- (59) a. $_{VP}[Ee V(e):...(e)] INFL(e, NP)$ the sum of plurals
 b. $_{VP}[Ae V(e):...(e)] INFL(e, NP)$ event-dependent quantification
 c. $_{NP}[Q(x, e)N(x):...(x)] \Diamond(x, e)$ quantification over individual objects,
 of which non-event-dependent quantification is a special case

In (59a) and (59b), the quantifier and its restriction correspond to VP, and the quantifier is either existential or universal. One can view the alternation between existential and universal or generic as an aspectual choice made possible by the VP's lack of a specifier, that is, an intrinsic expression of quantity.¹⁹ In (59c), the subject NP, supplying an explicit expression of quantity, corresponds to the quantifier and its restriction in (57).

The following examples in (60) show various logical forms derived from (53) and their intended interpretation. Note that we assume the structure of VP in (59a) and (59b) to contain something like a relative clause, which is an opaque domain for quantifier raising. The example in (61) shows one of the logical forms which will turn out to represent Scha's (1981) cumulative quantification in (26). Cumulative quantification is discussed in an excursus in sec. 3.2.1.:

- (60) a. $_{VP}[Ee \text{ sell}(e): OF(e, 25 \text{ bldgs}) \text{ to}(e, 2 \text{ investors})] INFL(e, \text{ three agents})$
 (sum of plurals) "Three agents sold buildings to investors at e, and agents sold twenty-five buildings to investors at e, and agents sold buildings to two investors at e."

19. Compare the behavior of indefinites which also alternate between existential and universal or generic interpretations:

- (i) Dogs are man's best friend
 (ii) Dogs ran across the front lawn

See Carlson (1977).

- b. $\text{yp}[\text{Ae sell}(e): \text{OF}(e, 25 \text{ buildings}) \text{ to}(e, 2 \text{ investors})] \text{ INFL}(e, \text{three agents})$
 (event-dependent) "Any event of selling in which twenty-five buildings are sold and two investors are sold to has sellers who are three agents"
- c. $\text{NP}[3\langle x, e \rangle \text{ agent}(x)] \text{ INFL}(e, x) \text{ sell}(e) \text{ OF}(e, 25 \text{ buildings}) \text{ to}(e, 2 \text{ investors})$
 "Three agents each sold twenty-five buildings and sold them to two investors"
- d. $\text{NP}[3\langle x, e \rangle \text{ agnt}(x)] \text{ INFL}(e, x) [\text{sell}(e) [25\langle y, e \rangle \text{ bldg}(y)] [\text{OF}(e, y) \text{ to}(e, 2 \text{ invstrs})]]$
 "Three agents each sold twenty-five buildings each to two investors"
- e. $\text{yp}[\text{Ee sell}(e): [25\langle y, e \rangle \text{ building}(y)] [\text{OF}(e, y) \text{ to}(e, 2 \text{ investors})]] \text{ INFL}(e, 3 \text{ agents})$
 "Three agents together sold twenty-five buildings each to two investors"
- f. $[25\langle y, e \rangle \text{ building}(y)] [\text{INFL}(e, 3 \text{ agents}) [\text{sell}(e) \text{ OF}(e, y) \text{ to}(e, 2 \text{ investors})]]$
 "Twenty-five buildings were each sold by three agents and sold to two investors"
- g. $[25\langle y, e \rangle \text{ building}(y)] [[3\langle x, e \rangle \text{ agent}(x)] [\text{INFL}(e, x) [\text{sell}(e) \text{ OF}(e, y) \text{ to}(e, 2 \text{ investors})]]]$
 "Each of 25 buildings is such that 3 agents each sold it to 2 investors"
- (61) $[500\langle x, e \rangle \text{ Dutch firm}(x)] \text{ INFL}(e, x) [\text{buy} [600\langle y, e \rangle \text{ Am computer}(y)] [\text{OF}(e, y)]]$
 (cumulative quantification) "Exactly 500 Dutch firms bought American computers, and exactly 600 American computers were bought by Dutch firms."

We turn now to the interpretation of the logical forms. We define when a logical form is true in a given context or domain of events C. The structure of such a domain of events is discussed in sec. 3.4. For what follows, we need to point out that an event may itself be a domain of events, containing constituent subevents. Consider the intended interpretation of (60e). Here there is a scope relation between "twenty-five buildings" and "two investors": twenty-five buildings were each sold to two investors. According to (60e), this state of affairs was brought about by three agents' selling; but the interpretation leaves open which agents were responsible for which sales. Thus, the matrix logical form of (60e) is that of a sum of plurals, as in (59a): some event of selling's sellers are three agents. As (60e)

shows, the scope relation between "twenty-five buildings" and "two investors" elaborates the description of that event of selling. Since, the complex quantifier "[25<y,e>: building(y)]" quantifies over individual objects and events, that event of selling must itself be composed of subevents of selling--exactly twenty-five, one for each building, in which the building is sold to two investors.²⁰

In the clauses in (64) interpreting the complex quantifiers over individual objects and events, we make use of a primitive semantic function "I(x, c)": the value of I(x,c) is what the individual object x did in the context of events c. It is assumed that people have the cognitive ability to pick out from a domain of events what an individual has done there. What he has done may itself meet the conditions defining an event of some kind. The interpretation of a complex quantifier requires that it do so. Thus, for a domain of events C, the complex quantifier "[three<x,e>:agent(x)]" in (60d) will require that what each of three agents did in C is itself an event of selling twenty-five buildings to two investors.

The clauses in (64) treat a number of different interpretations as an ambiguity in the same logical form. Alternative treatments, especially those that take into account how aspectual markers and particular lexical items

20. In sec. 3.4., it will be seen that a domain for quantification over events consists of discrete individual events, none of which is part of another event in that domain. This is not contradicted by the discussion above. What is found there is a nesting of distinct domains. Within each domain no event is part of another. Thus, none of the constituent subevents of selling one building to two investors, which belong to the domain of events for the quantifier "[25<x,e>:building]", belongs to the domain for the quantifier "[Ee sell(e):...]" which includes the matrix event of selling by three agents.

select these interpretations, might contain disambiguated logical forms instead. The first two clauses of (64) allow for an aspectual ambiguity discussed in sec. 5.2. (64a) is about what an individual did throughout his history, that is, across all the events of the domain; and (64b) is about what he did within some event. The third clause of (64) is the special case of quantifying over individual objects and events that we have called non-event-dependent quantification. The fourth clause covers Scha's (1981) cumulative quantification, discussed in sec. 2.4.1. and in sec. 3.2.1 below.

Three remarks on the notation. First, the clauses interpreting complex quantifiers have three factors: the complex quantifier "[Q(α, e) N']", the theta role it binds into " $R(\alpha, e)$ ", and the remainder of the sentence " $\Phi(e)$ ". For the sake of "inverse scope" as in (60f) and (60g), the notation " $\langle R(e, \alpha); \Phi(e) \rangle$ " allows the theta role to be ordered anywhere among the constituents of the remainder. Second, a value for a variable, e.g., e replaces it in " $\Phi(e)$ " just in case the variable is free in " Φ ". Note that in (60d), the variables in " $OF(e, y)$ to($e, 2$ investors)" are not free in the formulas which are the scope of the matrix quantifier. Third, clauses (62), (63) and (64c) on the right side of their biconditionals attach asterisks to formulas. (64) and (65) are really schemas for interpreting formulas with and without the asterisk. Thus, formulas marked by the asterisk have the interpretation in (64) including the condition within the angled brackets on the right hand side, and formulas without the asterisk are interpreted without this condition. In (65) and (64d), formulas with and without the asterisk are interpreted in the same way. The need for this embarrassing detail is explained in the following section.

- (62) " $\cup_P[Ee \vee(e): \phi(e)] \psi(e)$ " is true in C iff for some event E in C,
" $\vee(E)$ " is true in E, and " $\phi(E)*$ " is true in E, and " $\psi(E)$ " is true in E.
- (63) " $\cup_P[Ae \vee(e): \phi(e)] \psi(e)$ " is true in E iff for any event E in C,
if " $\vee(E)$ " is true in E and " $\phi(E)*$ " is true in E, then " $\psi(E)$ " is true in E.
- (64) a. " $_{NP}[Q(x,e) N'(x)] (R(e,x); \phi(e))(*)$ " is true in C iff
Q N'-many (and only Q N'-many) individuals a are such
that " $R(I(a,C), a)$ " is true in $I(a,C)$ and " $\phi(I(a,C))$ " is true in $I(a,C)$.
- b. " $_{NP}[Q(x,e) N'(x)] (R(e,x); \phi(e))(*)$ " is true in C iff
Q N'-many (and only Q N'-many) individuals a are such that
for some event E in C, " $R(I(a,E), a)$ " is true in $I(a,E)$ and
" $\phi(I(a,E))$ " is true in $I(a,E)$.
- c. (non-event-dependent quantification)
" $_{NP}[Q(x,e) N'(x)] (R(e,x); \phi(e))(*)$ " is true in C iff
Q N'-many (and only Q N'-many) individuals a are such that
for some event E in C and some individuals A among which is a
" $R(E, A)$ " is true in E and " $\phi(E)*$ " is true in E.
- d.i. (cumulative quantification (Scha 1981))
" $_{NP}[Q(x,e) N'(x)] (R(e,x); \phi(e))(*)$ " is true in C iff
" $\phi(C)$ " is true in C and Q N'-many and only Q N'-many individuals a
are such that " $R(I(a,C), a)$ " is true in $I(a,C)$.
- d.ii. (cumulative quantification with collective predicates)
" $_{NP}[Q(x,e) N'(x)] (R(e,x); \phi(e))(*)$ " is true in C iff
" $\phi(C)$ " is true in C and Q N'-many and only Q N'-many individuals a
are such that there is some event E in C and some individuals A
among which is a and " $R(E, A)$ " is true in E.
- (65) " $\phi_1(E) \dots \phi_n(E)(*)$ " is true in E iff
" $\phi_1(E)$ " is true in E and...and " $\phi_n(E)$ " is true in E.

(66) "V(E)" is true in E iff E is an event of V-ing.

(67) "R(E, NP)" is true in E iff E's R-ers are NP.

(68) "R(E,a)" is true in E iff E's R-ers are a.

3.1.1

In any logical form such as (60a) and (60b), the interpretation of an expression like "INFL(e, three agents)", where the NP has remained in place, is as we have seen earlier "e's sellers are three agents". It is an exhaustive description, true of an event if and only if three agents and no others were its sellers. It is easy to show that the description must be exhaustive. We cannot allow "three agents were sellers in e." Suppose to the contrary that the expressions "R(e,NP)" could be so interpreted and consider its effect on the interpretation of the logical form in (69), representing the sum of plurals interpretation of (70):

(70) The three agents sold the three buildings

(69) [Ee sell(e): OF(e, the three buildings)] INFL(e, the three agents)

If "INFL(e, the three agents)" and "OF(e, the three buildings)" is so interpreted, (69) would allow the three agents to be involved in the event with others and, similarly, the three buildings to be involved in the event with others. But, in not excluding other agents and other buildings, (69) assigns faulty truth conditions to (70). The truth conditions would be satisfied in a situation where the three agents sold only buildings other than the three and the three buildings were sold only by agents other than the three; but, sentence (70) is false in this situation. To be certain that the selling of the three buildings is by the three agents, we must require as

in (67) that other participants are excluded. 21

Now recall the logical form in (60e):

[Ee sell(e):[the 25(y,e) bldg(y)][OF(e,y) to(e,2 invstrs)]] INFL(e, the 3 agts)

"The three agents together sold the twenty-five buildings each to two investors"

An event that satisfies its interpretation is one in which the twenty-five buildings were each sold to two investors and whose sellers are the three agents. The interpretation of "INFL(e, three agents)" according to (67) will correctly require that three agents are the only sellers in the event; but nothing yet said about the interpretation of complex quantifiers will require there to be only twenty-five buildings, although the need for this requirement is the same. Suppose that the restriction on the quantifier in (60e) were true of any event that contained at least the twenty-five buildings each of which is sold to two investors. Then, the (60e) is true if the sellers of one such event are three agents. (60e) would be true of a situation in which the three agents sold buildings to investors, but just one of them, without involving in any way the other two, sold the twenty-five

21. It would at first appear that the interpretation in (ii) of any symmetric predicate (i) is false:

(i) The boys met the girls

(ii) [Ee meet(e): OF(e, the girls)] INFL(e, the boys)

The boys and the girls did the same thing, and (ii) appears to require of any event that would confirm it that all those who met are the boys and all those who met are the girls. It shows instead that an event confirms (ii) under a particular description-- one that divides its participants into meeters and met. Since the predicate is symmetric, the meeters and the met do in fact do the same thing, and therefore any event that confirms (ii) under one description will also confirm (iii) under another:

(iii) The girls met the boys

buildings. The interpretation would fail to require that the three agents' selling was of the twenty-five buildings. we will therefore also want the interpretation of the complex quantifier "[25<y,e> building(y)]" in (60e) to require the event to be one in which exactly twenty-five buildings were each sold to two investors. It too should be an exhaustive description of the event. Note that we cannot simply assume a complex quantifier to always have this interpretation, otherwise (60d), for example, would always mean that three any only three agents each sold twenty-five and only twenty-five buildings each to two investors. We have used the asterisks to mark those contexts that require the exclusive interpretation.

A NP that has moved as in (60c) to become a complex quantifier over individual objects and events binds into a theta role expression, such as "INFL(e,x)", whose interpretation according to (68) exhausts the event e's participants in that role. Thus, if the value of x in (60c) is an individual "him", the interpretation of the theta role is "e's sellers are him". This is necessary to accommodate familiar scope interactions. (71) is not satisfied if there is an event of solving two crimes in which two detectives participated but failed to each solve two crimes:

(71) Two detectives each solved two crimes

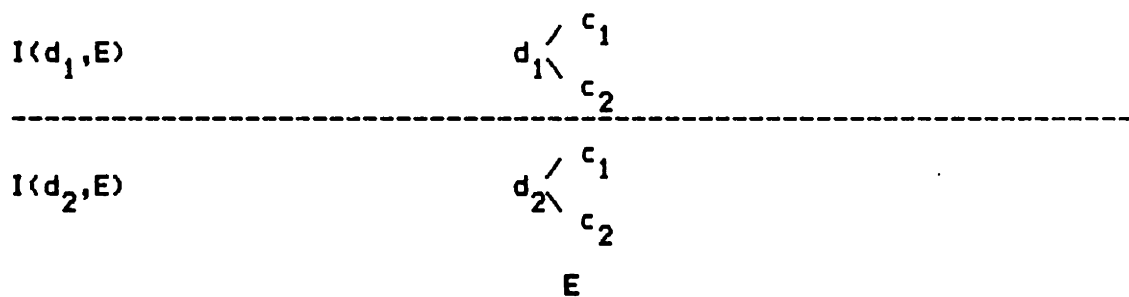
(72) [two<x,e>;detective(x)] INFL(e,x)[solve(e) OF(e, two crimes)]

But, such an event would satisfy the interpretation represented by (72) if "INFL(e,x)" were to be interpreted as "x is a seller in e."

(64a) and (64b) in conjunction with the interpretation in (68) of theta role expressions has the effect that quantifying over individuals in the familiar scope interpretations is quantifying over individuals each of whom

has his own (sub)event e_i in which he is the only one in his role. Thus the interpretation of (71) with the scope relation shown in (72) is true just in case there are subevents, each a solving of two crimes by one of the two detectives, that are disjoint. It excludes in particular the following. Suppose that E in (73) below is an event in the given context in which the two distinct detectives shown each solve two crimes. We may even let them solve the same crimes so that E is itself an event of solving two crimes. The interpretation of (71) represented by (72) is certainly true in (73). But, its truth follows from the sentences in (74) about the disjoint subevents $I\langle d_1, E \rangle$ and $I\langle d_2, E \rangle$:

(73)



(74) $\text{INFL}\langle I\langle d_1, E \rangle, d_1 \rangle \text{ solve}\langle I\langle d_1, E \rangle \rangle \text{ OF}\langle I\langle d_1, E \rangle, 2 \text{ crimes} \rangle$;

$\text{INFL}\langle I\langle d_2, E \rangle, d_2 \rangle \text{ solve}\langle I\langle d_2, E \rangle \rangle \text{ OF}\langle I\langle d_2, E \rangle, 2 \text{ crimes} \rangle$

(75) $\text{INFL}\langle E, d_1 \rangle \text{ solve}\langle E \rangle \text{ OF}\langle E, 2 \text{ crimes} \rangle$;

$\text{INFL}\langle E, d_2 \rangle \text{ solve}\langle E \rangle \text{ OF}\langle E, 2 \text{ crimes} \rangle$

Although E is an event in which the two detectives each solved two crimes, the sentences in (75) are false, since neither detective d_1 nor detective d_2 is the only solver in E.

3.2

An important and characteristic feature of event logic is the way in which the expression of an NP's theta role associates with the NP. In the logical forms for the sum of plurals and event-dependent quantification in (59a) and (59b), the theta role assigned to NP, "INFL(e,NP)" is dissociated from the quantifier over events VP. The restriction on the quantifier over events contains no argument place bound by NP. Similarly, when interpreting a complex quantifier NP according to (64), the theta role it binds into is dissociated from the remainder of the sentence, which again has no argument place bound by the NP. The logical forms for the sum of plurals and event-dependent interpretations of (31) are paraphrased in (76) and (77):

(76) Some event of selling in which its sold are twenty-five buildings and its sellees are two investors is such that its sellers are three agents.

(77) Any event of selling in which its sold are twenty-five buildings and its sellees are two investors is such that its sellers are three agents.

And a paraphrase of event logic's non-event-dependent interpretation of (11a) is in (78):

(11) c. Few unionists gathered in the square

(78) Few unionists are gatherers in any event of gathering in the square.
(by (64c))

Note that the restriction on the event quantifier contains no argument place

for any NP that it does not contain.²² One can come to see this dissociation of an NP's theta role from the remainder of the sentence " $\Phi(e)$ " in (62)-(64) as one way to realize Leibniz's view of predication. According to Sommers(1982), Leibniz treated any polyadic sentence as a nesting of monadic predications. Thus, the sentence "Paris loves Helen" has the logical form "Paris loves, and eo ipso Helen is loved." The main "trick" of event logic, its use of the variable over events, in a sense formalizes Leibniz's "eo ipso". Leibniz's logical form does not contain a relation between individual objects " $L(x,y)$ " (or, " $L(x,y,e)$ "). Note in particular that the conjunct "eo ipso Helen is loved" contains no theta role or argument place assigned to "Paris" or to a variable bound by "Paris". The theta role assigned to "Paris", viz. "loves (in e)", is not part of the remainder of the sentence.

This contrasts with the syntax of set-denotative logic. As we have seen, it assumes that the NPs of a simple sentence are all related to argument positions in an atomic and polyadic predicate. The verb, wherever it occurs in logical form, must appear with its full valence of theta roles or argument positions. This syntactic aspect of set-denotative logic will remain a defining characteristic, although we will consider alternative versions of

22. Recall from sec. 2.4.2 that we allow the verb to stand as an abbreviation for a complex predicate, paraphrased better by (76')-(78'):

(76') Some event of agents selling buildings...

(77') Any event of agents selling buildings...

(78') Few unionists are gatherers in any event of unionists
gathering in the square.

In (78'), for example, "unionists" in "unionists gathering..." is however not an argument position bound into by the NP "few unionists".

set-denotative logic that are more like event logic in other respects. In chapter 6, for example, we will consider an alternative set-denotative logic that admits events and a Davidsonian decomposition of polyadic verbs in the lexicon (but not in logical form). In this alternative, quantification involves variables over sets, x_i , and variables over events, e . The logical form of any simple sentence contains a prefix of quantifiers over sets and events and a polyadic atomic predicate:

(79) $NP_i x_i \dots Ee \dots NP_j x_j \ V(x_i, \dots, e, \dots x_j)$

Except for quantifying over events, the logical syntax is as before.

Davidsonian decomposition comes in only to regiment how we then interpret the atomic polyadic sentences. That is, for every lexical verb, there is an event concept " $V'(e)$ " and theta roles " $R_i(x_i, e)$ ", ..., " $R_j(x_j, e)$ " which determine the truth conditions for the polyadic atomic sentences:

(80) " $V(c_i, \dots, e, \dots c_j)$ " is true iff $V'(e)$ and $R_i(c_i, e)$ and ... and $R_j(c_j, e)$

If we were to replace " V " in (79) by its collection of event concept and theta roles, the logical form of every simple sentence would be equivalent to (81):

(81) $NP_i x_i \dots Ee \dots NP_j x_j \ (V'(e) \ \& \ R_i(x_i, e) \ \& \ \dots \& \ R_j(x_j, e))$

Note however that a set-denotative logical form does not have separable expressions for the theta roles and the event concept whatever the meaning of its predicate may be. It has only the atomic and polyadic predicate " $V(x_i, \dots, e, \dots x_j)$ ", which, wherever it occurs, expresses the event concept and all the theta roles. In contrast to the event logic's " $\Phi(e)$ " in (62)-(64), the interpretation of a set-denotative logical form never uses a formula that contains the expression of an event concept with less than its

full valence. In interpreting a sentence, any (sub)formula that contains "V" must contain a place for every NP in the sentence.

All set-denotative logics demonstrate this property; but it is best to compare the alternative from chapter 6 to event logic because it is similar to event logic in the other respects noted. So compare the paraphrases of the set-denotative logical forms in (82), (83) and (84) with the event logic's (76)-(78):

- (82) Three agents are such that there is some event of selling in which its sellers are them and its sold are twenty-five buildings and its sellees are two investors.
- (83) For any set of individuals, if there is some event of selling in which its sellers are them and its sold are twenty-five buildings and its sellees are two investors, they are two agents.
- (85) Few unionists are in any set of individuals for which there is an event of gathering in the square in which the gatherers are them.

In these paraphrases, the relative clauses restricting events "event of selling in which..." contain places for every NP in the sentence (31). These are bound either within the relative clause ("twenty-five buildings" and "two investors") or from outside ("them"). We never find in the set-denotative logic that a theta role is in a sense subtracted from the clause restricting events when that clause does not contain the theta role's NP. We never find descriptions such as "events of selling twenty-five buildings to two investors" that are indifferent to who the sellers are.²³

We argue in chapter 6 for the syntax of event logic.

23. Accommodating the contextual dependence of the verb discussed in sec. 2.4.2., the descriptions should be paraphrased as "events of agents selling twenty-five buildings to two investors". The description is indifferent to how many and who the agents are.

3.2.1 Excursus: cumulative quantification

The cumulative quantification of (26) is true if and only if exactly 500 Dutch firms bought American computers and exactly 600 American computers were bought by American firms.

(26) 500 Dutch firms bought 600 American computers

Cumulative quantification is derived from the logical form in (61) when at least the first quantifier is interpreted according to (64d). This is so provided that the event concept and its theta roles are complex in the sense of sec. 2.4.2. Hence, "INFL(e,x)" in (61) has the interpretation "e's American computer buyers are x" rather than the simple "e's buyers are x". Interpreting the first quantifier according to (64d) then gives "[600(y,e)American computer(y)] buy OF(e,y)" is true in C and exactly 500 Dutch firms are American computer buyers in C.

The clauses in (64d) apply to other classes of quantifiers as well. They will, for example, derive from the decreasing quantifiers that interpretation of nobody loves nobody that means nobody loves, and nobody is loved. From two men love no women, it will derive the contradictory interpretation that exactly two men love women and no women are loved by men. An entirely parallel derivation assigns to two men love no more than ten women the non-contradictory interpretation that exactly two men love women and no more than ten women are loved by men.

If (64d) is the correct treatment of cumulative quantification, it suggests the following revision in how we view the complex atomic predicate consisting

of the event concept and its theta roles.

(86) no one arrived

Note that (86) does not have the contradictory interpretation that "arrive(C)" is true in C and no one is an arriver in C, which (64d) would derive from the logical form in (87):

(87) [no(x,e):person(x)] INFL(e,x) arrive(e)

The lack of the contradictory interpretation when there is only one quantifier suggests that the verb in structures such as (87) should not stand by itself as a predicate on events. (64d) would not derive the contradictory interpretation from (88) where the verb does not provide a position for events:

(88) [no(x,e):person(x)] INFL-arrive(e,x)

The logical structure of the intransitive consists of just the complex theta role. No information is lost, since it must be the case that e's arrivers are x only if e is itself an arriving. But, interpreting (88) according to (64d) has only the interpretation that no one is an arriver in C, without contradiction.

Cumulative quantification in sentences with more than one quantifier proceeds as before. The verb in (61) appears without an event variable. In the style of (88), we might render it as in (89).

(61) [500(x,e) Dutch firm(x)] INFL(e,x) [buy [600(y,e) Am computer(y)][OF(e,y)]]

(89) [500(x,e) Dutch firm(x)] INFL-buy(e,x) [600(y,e) Am cmptr(y)][buy-OF(e,y)]]

Applied to the first quantifier, (64d) derives that exactly 500 Dutch firms bought American computers in C, and "[600(y,e) Am cmptr(y)][buy-OF(e,y)]]" is

true in C, which is in turn interpreted as saying that exactly 600 American computers are bought by Dutch firms in C.

(90) No one bought American computers

Again supposing (64d) to be correct, the lack of a contradictory interpretation for (90) shows in a way parallel to the discussion of (86) that the logical form of (90) must be intransitive: "American computers" is not quantificational, contributing only to the formation of the underlying event concept and the complex theta role that appears overtly in (91).

(91) [no(x,e):person(x)] INFL-buy-American computers(e,x)

We are free to revise all the logical forms so that the event concept is not directly predicated of an event, except for logical forms in which the verb heads a quantifier over events. It is crucial for the event-dependent interpretations (59b) of sentences with just one NP that the verb provide a bindable position in the restriction on the event quantifier. Consider, for example, the event-dependent interpretation of no more than two experts (ever) agree, according to which any agreement consists of no more than two experts. We will however for convenience keep the verb's event variable in all logical forms that do not represent cumulative quantification.

A shortcoming of this approach to cumulative quantification is that, like Scha's compound numerals, it does not assimilate cumulative quantification and the sum of plurals. Failing this, I have no objection to Scha's special use of n-ary quantifiers for cumulative quantification provided that predicates in the scope of such n-ary quantifiers are treated like those in event logic in the crucial respects discussed in sec 3.2., showing a Davidsonian decomposition and separating the theta roles from the remainder

" $\Phi(e)$ ";

(64d.i.'):

"[500<x,e>:Dutch firm(x)]X[600<y,e>:Am computer(y)] R(e,x); S(a,y); $\Phi(e)$ " is

true in C iff " $\Phi(C)$ " is true in C, and

exactly 500 Dutch firms a are such that " $R(I(a,C), a)$ " is true in $I(a,C)$, and

exactly 600 Am. computers b are such that " $S(I(b,C), b)$ " is true in $I(b,C)$.

Introducing n-ary quantifiers could accomodate whatever co-occurrence restrictions there are on the constituents of a cumulative quantification. N-ary quantifiers would also result in a different mapping between the syntactic structures of logical forms and particular types of interpretations-- one closer to that of May (1985).

Assimilating the sum of plurals and cumulative quantification, one would have liked to analyze (92)'s sum of plurals as (93), and (94)'s cumulative quantification as (95):

(92) The two detectives solved the two crimes

(93) The two detectives solved crimes there, and
there detectives solved the two crimes.

(94) No more than two detectives solved no more than two crimes

(95) No more than two detectives solved crimes there, and
there detectives solved no more than two crimes.

The reference of the demonstrative there is however different in the two cases. For the sum of plurals, both occurrences in (93) must refer to some one event in the context of events. Were there to refer to the context itself, (93) would mean that the two detectives solved crimes somewhere in that context, and somewhere in there detectives solved the two crimes. It does not mean that the two detectives solved the two crimes, unless there

refers in both conjuncts to the same event. For cumulative quantification in (95), there must refer to the context itself, since cumulative quantification puts an upper bound on whatever happened. Reference to an individual event would result in the much weaker interpretation that there is some event in which no more than two detectives solved no more than two crimes.

It is clear that cumulative quantification is not to be assimilated to the pattern for the sum of plurals in (59a). The cumulative quantification cannot be within the scope of any quantifier over individual events. Schein (in progress) considers assimilating the sum of plurals to the pattern for cumulative quantification and the familiar scope interpretations:

(i) (sum of plurals) "NP(x) (R(e,x); $\Phi(e)$)(*)" is true in C iff

for some event E in C " $\Phi(E)$ *" is true in E and "R(E, NP)" is true in E.

(i) retains the aspects of event logic defended in this work, the Davidsonian decomposition and the formula factored into theta role and remainder. See sec. 3.2.

3.3

We now explain the choice of complex quantifiers to represent the scope interactions between quantifiers over individual objects. Two interpretations of (96) exemplify these familiar cases:

(96) Two detectives solved two crimes

- (97) a. [two detectives(x)][two crimes(y)] x solved y
 b. [two crimes(y)][two detectives(x)] x solved y

In one interpretation ((97a)), "two detectives" has within its scope "two crimes"; hence, two detectives each solved two crimes. In the other ((97b), "two crimes" has within its scope "two detectives", and so two crimes were each solved by two detectives.

In representing the scope interactions of two quantifiers over individual objects, one must be careful, if one accepts a Davidsonian decomposition of polyadic predicates, with the assignment of scope to the quantifier over events. For, within the scope of a quantifier over events, quantifiers over individual objects will interact in unintended and undesirable ways.

Consider (98) and the schema in (99), where the event quantifier includes within its scope two quantifiers over individual objects:

(98) $\text{Ee } [Q \text{ detectives}(x)][Q' \text{ crimes}(y)] \text{ } \diamond (\text{solver}(x,e) \ \& \ \text{solving}(e) \ \& \ \text{solved}(y,e))$

(99) $\text{Ee } [Q \text{ N}'(x)][Q' \text{ N}'(x)] \text{ } \diamond (R(x,e) \ \& \ U(e) \ \& \ S(y,e))$

We must here assume that the theta roles, at least when they appear with an individual variable, as in "solver(x,e)", do not exclude other participants. This one is to be interpreted as "x is involved in e as a solver" or equivalently, as "x is one of e's solvers". It cannot have the exclusive interpretation "e's solvers are x". Otherwise, a quantifier over individuals within the scope of the event quantifier, such as "two detectives" in "Ee[two detectives(x)]...solver(x,e)", would require some event to contain two detectives who were each the only solver in that event. Since, a sentence like (96) does not have a logically false interpretation, we must assume that the theta role "solver(x,e)" does not exclude other participants. Likewise for the other theta roles.

Now the Davidsonian decomposition into a conjunction eliminates the

possibility of expressing a proper relation between the individuals of any given event. That is, (100) and (101) are always the case for any choice of an event E:

(100) $\langle x_1 \rangle \langle x_2 \rangle \langle y_1 \rangle \langle y_2 \rangle$

$[\text{solver}(x_1, E) \ \& \ \text{solving}(E) \ \& \ \text{solved}(y_1, E)] \ \& \ [\text{solver}(x_2, E) \ \& \ \text{solving}(E) \ \& \ \text{solved}(y_2, E)] \quad \rightarrow$

$[\text{solver}(x_1, E) \ \& \ \text{solving}(E) \ \& \ \text{solved}(y_2, E)] \ \& \ [\text{solver}(x_2, E) \ \& \ \text{solving}(E) \ \& \ \text{solved}(y_1, E)]$

(101) $\langle x_1 \rangle \langle x_2 \rangle \langle y_1 \rangle \langle y_2 \rangle$

$\langle [R(x_1, E) \ \& \ V(E) \ \& \ S(y_1, E)] \ \& \ [R(x_2, E) \ \& \ V(E) \ \& \ S(y_2, E)] \rangle \rightarrow$

$[R(x_1, E) \ \& \ V(E) \ \& \ S(y_2, E)] \ \& \ [R(x_2, E) \ \& \ V(E) \ \& \ S(y_1, E)]$

Every solver in E is related by Φ in (98) to every thing solved in E. The extension of Φ for a given event is always a Cartesian product. The effects of this on logical forms such as (98) and (99) fall into two cases.

In the first case, the quantifiers within the scope of the event quantifier are both non-decreasing, as in (102) and (103), which are logical forms for (96), and as in (105) and (106), which are logical forms for (104)²⁴:

(102) $Ee[2 \text{ detectives}(x)][2 \text{ crimes}(y)] \ \Phi \ (\text{solver}(x, e) \ \& \ \text{solving}(e) \ \& \ \text{solved}(y, e))$

(103) $Ee[2 \text{ crimes}(y)][2 \text{ detectives}(x)] \ \Phi \ (\text{solver}(x, e) \ \& \ \text{solving}(e) \ \& \ \text{solved}(y, e))$

(104) Exactly two detectives solved exactly two crimes

(105) $Ee[2! \text{ detectives}(x)][2! \text{ crimes}(y)] \ \Phi \ (\text{solver}(x, e) \ \& \ \text{solving}(e) \ \& \ \text{solved}(y, e))$

(106) $Ee[2! \text{ crimes}(y)][2! \text{ detectives}(x)] \ \Phi \ (\text{solver}(x, e) \ \& \ \text{solving}(e) \ \& \ \text{solved}(y, e))$

When they are all non-decreasing, the different scope assignments to the

24. Also, "the detectives", "three and no more than three crimes", "some detectives", etc.

quantifiers within the scope of the event quantifier result in logically equivalent logical forms. Any event E that confirms (102) satisfies (107) and therefore confirms (103).

(107) Two detectives solve crimes in E, and
Two crimes are solved by detectives in E.

For suppose E is an event confirming (102). It then contains two detectives that each solved (as represented by \diamond in (98)) two crimes. It therefore satisfies (107), containing two detectives solving crimes and (at least) two crimes solved by detectives. But, by (100), every crime in E is related to every detective in E. Thus, E confirms (103), since it contains two crimes that were each solved (as represented by \diamond) by two detectives. Similar remarks show the reverse entailment from (103) to (102).

The same argument but for one additional remark shows that (105) and (106) are equivalent. Any event E that confirms (105) satisfies (108), and therefore confirms (106).

(108) Exactly two detectives solve crimes in E and
exactly two crimes are solved in E

The event E that confirms (105) contains exactly two detectives that each solved exactly two crimes. Hence, at least two detectives solve crimes in E, and at least two crimes are solved by detectives in E. But, since by (100), every detective in E solved every crime in E, it contains no more than two crimes solved by detectives, for two detectives have each solved exactly two. Thus, exactly two crimes are solved in E. Similarly, E contains no more than two detectives that solve crimes. Any additional detective that solves crimes in E solves every crime in E, of which there are exactly two. But, according to (105), there are in E two and no more than two detectives who

each solve exactly two crimes. Hence, E satisfies both conjuncts in (108), and one can proceed as above to show that E then confirms (106). The reverse entailment is similarly shown.

The equivalences we have seen, between (102) and (103) and between (105) and (106), show that the assignment of scope to quantifiers within the scope of an event quantifier as in (98) will not represent the interpretations in (97) in which they interact. Representing these interpretations when the predicate is decomposed as in (98) requires the event quantifier to be within the scope of at least one of the quantifiers over individual objects:

(109) $[Q \text{ detectives}(x)]Ee[Q' \text{ crimes}(y)] \text{ } \text{ } (\text{solver}(x,e) \ \& \ \text{solving}(e) \ \& \ \text{solved}(y,e))$

(110) $[Q \text{ detectives}(x)][Q' \text{ crimes}(y)]Ee \text{ } \text{ } (\text{solver}(x,e) \ \& \ \text{solving}(e) \ \& \ \text{solved}(y,e))$

In (109) and (110), one chooses for each detective his own event(s) of solving Q' crimes. Since, (100) holds only within the individual event, it is not the case that every one of the Q detectives solves every crime solved by any of the others. And so it cannot be concluded that Q' crimes were each solved by Q detectives. Reversing the positions of the quantifiers over individual objects will then result in a distinct interpretation.²⁵ Thus, to properly quantify over individuals, if we accept the Davidsonian decomposition of the predicate, is to quantify over events. In a sentence such as (111), which has only the interpretation in (97a), each must include within its scope the quantifier over events:

25. The scope of the event quantifier in (109) or (110) is necessary if the interpretations of (97) are to be represented; but, (109) and (110) are not sufficient unless "solver(x,e)" is interpreted exclusively, "e's solvers are x", see sec. 3.1.1.

(111) Two detectives each solved two crimes.

The quantifiers over individual objects considered in the first case are all non-decreasing. As we have seen, the assignment of scope to these quantifiers within the scope of the event quantifier does not represent the familiar scope interactions in (97). The interpretations that do result are however benign. As their necessary and sufficient truth conditions in (107) and (108) show, the logical forms corresponding to (98) are equivalent to the sum of plurals interpretations of the sentences (96) and (108).

In the second case where (98) (or (99) includes at least one decreasing quantifier, the resulting interpretation is wholly anomalous. It does not correspond to any of the sentence's acceptable interpretations. We consider the following examples and the logical forms which are instances of (98):

(112) (Exactly) two crimes were solved by no more than two detectives

(113) No more than two detectives solved (exactly) two crimes

(114) $Ee[2(!)crimes(x)][\leq 2\ detectives(y)]\ solver(x,e) \ \& \ solving(e) \ \& \ solved(y,e)$

(115) $Ee[\leq 2\ detectives][2(!)crimes(x)](y)\ solver(x,e) \ \& \ solving(e) \ \& \ solved(y,e)$

(116) No more than two detectives solved no more than two crimes

(117) $Ee[\leq 2\ detectives(x)][\leq 2\ crimes(y)]\ solver(x,e) \ \& \ solving(e) \ \& \ solved(y,e)$

(118) $Ee[\leq 2\ crimes][\leq 2\ detectives(x)](y)\ solver(x,e) \ \& \ solving(e) \ \& \ solved(y,e)$

Consider first the forms in (115), (117) and (118) in which a decreasing quantifier includes within its scope another quantifier over individual objects. Necessary and sufficient conditions for any event E to confirm these forms are given in the following:

(119)[(115)] No more than two detectives solved crimes in E, or there are not (exactly) two crimes solved by detectives in E.

(120)[(117)] No more than two detectives solved crimes in E, or there are not no more than two crimes solved by detectives in E.

(121)[(118)] No more than two crimes were solved by detectives in E, or there are not no more than two detectives that solved crimes in E.

We show that (119) is necessary and sufficient for (115). Assuming first that E confirms (115), we show that (119) is true. Suppose it to be false. Then, more than two detectives solved crimes in E and (exactly) two crimes were solved in E. By (100), every one of the detectives in E solved (as represented by ϕ in (98)) every one of the crimes in E; and, therefore, more than two detectives each solved in E (exactly) two crimes. But, this contradicts the assumption that E confirms (115), and so (119) must be true. (119) is a necessary condition on any E that confirms (115).

Assuming now that (119) is true of E, we show that E confirms (115). If E satisfies the first disjunct of (119), it contains no more than two detectives solving crimes. It therefore contains no more than two detectives each solving two crimes. If, on the other hand, E satisfies the second disjunct of (119), there are not (exactly) two crimes solved by detectives in E. Then, there are in E no more than two detectives (in fact, none) who each solved (exactly) two crimes. Thus, (119) is a sufficient condition for (115). Similar remarks show that (120) and (121) are necessary and sufficient conditions for their corresponding logical forms.

As the truth conditions in (119), (120) and (121) make clear, the logical forms in (115), (117) and (118) do not represent acceptable interpretations of the sentences (112), (113) and (116). They do not represent interpretations reflecting familiar scope interactions:

(122) [no more than 2 detectives(x)][(exactly) 2 crimes(y)] x solved y

The detectives who according to (122) must be no more than two if they have solved (exactly) two crimes are not just those of some particular event. But, even if we could add a condition to (115) stipulating that the event e is the one event that includes all solving by any detectives of any crimes, (115) would still fail to represent (122). If more than two detectives solve crimes, (122) requires that all but two of them each solved not (exactly) two crimes. But, this is not to require as would (115) via (119) that there are not (exactly) two crimes solved by detectives.

As is evident from the disjunction in the truth conditions, these logical forms do not represent the sum of plurals interpretations either. The sum of plurals interpretation of (112) is true just in case an event of solving (exactly) two crimes is accomplished by no more than two detectives. But, (115) would be true of an event of solving fewer than two crimes accomplished by more than two detectives. Similarly, the sum of plurals interpretation of (116) is true of an event of solving just in case it involves no more than two detectives and no more than two crimes, but (117) would be true of an event of solving more than two crimes by more than two detectives. Unlike the first case with only non-decreasing quantifiers, these logical forms that fail to represent familiar scope interactions are not equivalent to other acceptable interpretations.

Consider now the remaining logical form (114) where the decreasing quantifier is within the scope of a non-decreasing quantifier over individuals. Note that for a particular event E , an individual crime has the property expressed by (123) if it was not solved in E or no more than two detectives solved crimes in E :

(123) [\exists 2 detectives(y)] solver(x , E) & solving(E) & solved(y , E)

A necessary and sufficient condition for E to confirm (114) is:

(124) (Exactly) two crimes are such [that they were not solved in E or no more than two detectives solved crimes in E].

As the brackets indicate, the relative clause in (124) is a disjunction. Note that if E is an event in which no more than two detectives solve crimes, then every crime is one that has the property in (123). Thus, if E is such an event, it confirms (114) if and only if there are (exactly) two crimes in the world. If, on the other hand, E is an event in which more than two detectives solve crimes, it confirms (114) if and only if there are (exactly) two crimes that are not solved in E . Plainly, (112) or (113) have no interpretations that are true if and only if: there is an event in which no more than two detectives solve crimes and there are (exactly) two crimes in the world, or there is an event in which more than two detectives solve crimes and there are not (exactly) two crimes solved in it. As above, the scope assignment in (98) where one of the quantifiers over individual objects is decreasing results in an anomalous interpretation.

The first cases of the schema in (98) where the quantifiers are all non-decreasing showed that to properly quantify over individual objects in the way of familiar scope interactions is, if one accepts the Davidsonian Φ , to quantify over events. The second cases of the schema in (98), with decreasing quantifiers, showed that within the scope of the event quantifier the interactions of quantifiers over individual objects are anomalous.²⁶

26. We have in fact shown more, viz., that the logical syntax implicit in Davidson (1968) cannot represent the sum of plurals interpretations of (112), (113) and (116). This is the syntax of (81) on p. 50 with the difference

Our acceptance of a Davidsonian decomposition of the predicate leads us to adopt a system of quantification that avoids the anomalous interactions. We have proposed complex quantifiers as in (60c). Any quantifier over individual objects is also a quantifier over individual events. In effect, every quantifier over individual objects is immediately followed by an existential quantifier over events. Thus, whenever a NP is taken to correspond to the quantifier A^* in (57), it binds, as shown in (125), the event variable that was free in the syntactic structure in (55).

(57) $A^*[Q\alpha A\alpha: \dots(\alpha)] B(\alpha)$

(55) $S[INFL(e, NP_1) \cup P[V(e) P_2(e, NP_2) P_n(e, NP_n)]]$

(125) $NP_2^{[Q(x, e): N'(x)]} S[INFL(e, NP_1) \cup P[V(e) P_2(e, x) P_n(e, NP_n)]]$

3.4

In the analysis of plurals, event logic replaces the sets of individuals that make up the domain of set-denotative logic with a domain of events, which "contain" participants. In this section, we consider what sort of individual events are.

that the values of x_k are only individual objects. The discussion in the text showed that logical forms in the schema of (98) are anomalous and, in particular, do not represent the sum of plurals interpretation. Any other ordering of the quantifiers over individuals with the event quantifier will yield a familiar scope interpretation. Thus, none of the forms in the schema in (8i) represent the sum of plurals interpretation of these sentences. The problem with this syntax is that the decreasing quantifier, whatever its scope relative to the other quantifiers, will always include within its scope the conjunction of the theta roles and event concept. Compare the event logic for the sum of plurals in (60a).

The events are Davidson's, which are understood to include states or situations. In The Logical Form of Action Sentences, he uses events to solve Kenny's (1963) problem of "variable polyadicity:"

(2) Jones buttered the toast in the bathroom with a knife at midnight.

...most philosophers today would, as a start, analyze this sentence as containing a five-place predicate with the argument places filled in the obvious ways with singular terms or bound variables. If we go on to analyze "Jones buttered the toast" as containing a two-place predicate, "Jones buttered the toast in the bathroom" as containing a three-place predicate, and so forth, we obliterate the logical relation between these sentences, namely that (2) entails the others. Or, to put the objection another way, the original sentences contain a common syntactic element ("buttered") which we intuitively recognize as relevant to the meaning relations of the sentences. But the proposed analyses show no such common syntactic element. (Davidson, op cit., p. 236.)

Davidson proposes that

...there is, of course, no variable polyadicity. The problem is solved in the natural way, by introducing events as entities about which an indefinite number of things can be said. (Davidson, op cit., p. 242.)

In the logical form of his example (2), each prepositional phrase says something about an event x. An existential quantifier, as Reichenbach (1947) suggested, binds the event variable:

(126) (Ex) (Buttered(J, the toast, x) & In(the bathrm, x) & With(a knife, x) & At(24h, x))

The logical relation of (2) to the other sentences that Davidson mentions is now clear. (126) entails their logical forms:

(127) (Ex) (Buttered(Jones, the toast, x))

(128) (Ex) (Buttered(Jones, the toast, x) & In(the bathroom, x))

The events quantified over include what one would ordinarily describe as

states or situations. As Davidson points out (pp. 243-244), the appearance of "variable polyadicity" is a common feature of verbs, not just of those that describe actions²⁷.

The analysis of plurals presented above assumes Davidson's commitment to events; but, in addition to interpretations such as (126)-(128), quantification over events is found in other contexts. In some interpretations, an existential quantifier over events is effectively within the scope of another quantifier, as in the interpretation of complex quantifiers "[Q(x,e): N'(x)] \exists (x,e)" (see (59c)), and in others, the variable over events is bound by a universal quantifier, "[\forall e U(e):... (e)] INFL(e,NP)" (see event-dependent quantification, (59b)). The analysis of plurals engages events in more of the apparatus of quantification theory than Davidson (1967) or Kroch (1974) first countenanced. It thus relies heavily on the assumption that in all ways required for quantification there are individual events²⁸.

In quantifying over individual objects, two sorts of domains have been recognized: domains of possible objects and domains of actual objects. We will see that this distinction also holds of events. There is quantification over a domain of possible events and quantification over a domain of actual

27. Harman (1972) notes that Davidson's event analysis may not be appropriate for all adverbial phrases. He suggests that, for example, 'necessarily' and 'intentionally' in "Necessarily Jack intentionally walked slowly in the street" take propositional complements.

For further discussion of Davidson's events and related questions of logical form, see Harman (1972) and Higginbotham (1984b).

28. The notion of individuation required for quantification and predication is discussed in Evans (1975). He analyzes the conditions under which a semantics can be said to require predication (of individuals).

events. Thus, events are like other individuals. This distinction between the possible and the actual will be of some importance in later sections, where we will rely on quantifying over a domain of actual events. But first we consider the more general question of what it means to be an individual.

Goodman (1956) observes that in a system of logical form such as the one considered here, to be an individual is to be a value of a variable. That is, to be an individual is to be denoted by some predicate, that is, an expression, perhaps complex, with a free variable $\phi(x)$. The question of how to identify individuals in the world pertains then to both events and objects. As Reichenbach (1947) and Goodman (1956) have remarked, a discourse (or theory) may take anything in the world to correspond to its individuals. Reichenbach's example is a house full of furniture. The individuals it contains are arms and legs to a joiner, but to a mover it contains one individual. Elaborating the example, the joiner's discourse is constructed from predicates, e.g., "x is joined to y", that denote arms and legs, which are the values of the variables. The joiner's individuals in the house of furniture are the arms and legs he talks about. On the other hand, the mover's discourse contains predicates, e.g., "x weighs a half ton over net allowance", which may denote all the contents of a house. Then, for the mover, all the furniture in the house is just one individual. Thus, the same thing in the world, the furniture in the house, may constitute one individual under some description and several individuals under another description. What is to be taken as an individual depends on the predicates. In this scheme of things, for something to be an individual does not fix its physical boundaries. It is left to the meaning of the particular predicate to specify that the individuals it denotes must have particular physical properties.

Thus, an individual x or y denoted by " x is joined to y ", being an arm or a leg, must occupy a continuous portion of space; but, an individual denoted by " x weighs a half ton over net allowance" does not have to have this property.

Events are no different from individuals in their dependence on predicates for physical definition (as Reichenbach notes). In admitting two sorts of variables those that range over events and those that range over objects, we have just divided the domain of individuals in two. To be an individual object is to be the value of a variable in a predicate about objects, and to be an individual event is to be the value of a variable in a predicate about events.²⁹ In the case of the variable that ranges over events, it is important to dispel the idea that there is some condition of spatial or temporal contiguity which must be met by whatever in the world is an individual event. The same activity in the world--whether it is, for example, the annual business of some moving company or the day's labor of one of its crews--may be truthfully described as an individual event by a loading of twenty-five trucks in one context and as a plurality of events by loadings of twenty-five trucks in another context.³⁰ To reject the existence of a spatial or temporal condition satisfied by all events does not prevent a particular predicate from imposing such a condition on the individual events

29. In this schema with two sorts, the predicates of the previous paragraph select variables that range over objects.

30. For the sake of illustration, I use nominalized forms, which mark plurality overtly. Roeper (1984) observes that the plural morpheme often cannot include within its scope the theme argument: the dropping of the baby vs. the droppings of the baby. The plural nominalization does not describe events in which the baby is dropped.

it denotes. Thus, the annual business of a moving company is unlikely to be an individual event for the predicate "x is a loading of trucks simultaneously", because the trucks belonging to such an event must be loaded simultaneously. But, that annual business may include several events that are denoted by the predicate. We have seen then that events are like objects. The notions that sort the domain of individuals, event and object, do not themselves impose physical or temporal boundaries.

3.5 Possible and actual individuals

Recall that sentences such as those in (129) have event-dependent and non-event-dependent interpretations, which quantify over a domain of individual events.

- (129) a. Few truckers load(ed) up one or more trucks.
 b. Only a few truckers load(ed) up one or more trucks.
 c. Not more than twenty truckers load(ed) up one or more trucks.
 d. (Exactly) twenty truckers load(ed) up one or more trucks.

(130)(ev.-dep.) [Ae: load(e) up one or more trucks] INFL(e, [Q truckers])

(131)(non-ev.-dep.)³¹ [Qx: trucker(x)][Ee: load(e) up one or more trucks] x ∈ e.

These interpretations count truckers who participated in events of loading one or more trucks. The domain of events quantified over thus includes individual events denoted by the predicate "load(ed) up one or more trucks(e)". The purpose of this section is to ask what is in the extension

31. I have altered the logical form to make it clear that (i) has been interpreted according to (64c) to give non-event-dependent quantification.

(i) [Q(x,e):trucker(x)][INFL(e,x) [load(e) up one or more trucks]]

of this predicate, for a given piece of the world such as the one depicted in (132) and described below, and what in this piece of the world must correspond to an individual event in the domain of events quantified over.

(132)

■	■	■	■	■	■	■	■	■	■
↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
0	0	0	0	0	0	0	0	0	0

Each block in (132) is a distinct truck, and the circle linked to it is its cargo. Suppose that several truckers loaded up each truck. Each loading of one truck with its cargo is an atomic event, or atom for short. As remarked above (p. 69), however distant in time and space the atoms are, what is depicted in (132) may be described as a single individual event in one context and as several individual events in another. What then are the individual events that (132) contributes to the domain quantified over in (130) and (131), which includes individual events of loading one or more trucks? Note that any non-empty combination of the atoms in (132), if it were an individual event, is a loading of one or more trucks and would therefore be denoted by the predicate "load(ed) up one or more trucks(e)". There are $1,023 (=2^{10}-1)$ such combinations. Is it necessary for the domain quantified over in (130) and (131) to include as individual events all of the 1,023 combinations? Suppose that the domain is always so comprehensive. Then, the event-dependent interpretation (130) will always yield truth conditions such as the one in (133) for (129d):

(133) (event-dependent) "Exactly twenty truckers load(ed) up one or more trucks" is true of (132) iff for any combination of the atomic events of (132), I, I involved exactly twenty truckers.

This has a surprising consequence. The atomic loadings are themselves each a combination of atomic events of (132). Then, according to (133), exactly

twenty truckers participated in each atomic loading. The atomic loadings taken all together are also one combination of the atomic events of (132), and so, according to (133), exactly twenty truckers participated in all of (132). These two consequences of (133) can be true only if it is the same twenty truckers in each atomic event. Thus, if the domain of events includes every combination of the atoms in (132), the event-dependent interpretation of (129d) will entail that the same twenty truckers and only these loaded up every truck.

We will see that a domain of individual events is not always closed under combinations of atomic events, and thus consequences like the one noted in the preceding paragraph do not in general obtain, fortunately. The question of what combinations of atoms correspond to individuals in the domain of quantification concerns not only events but also objects. In general, a domain of individuals closed under combinations of atoms is a domain of possible individuals. A domain of actual individuals is not closed under all combinations. We first show how quantifiers over objects sometimes have domains of possible individuals and sometimes domains of actual individuals. It will then be shown that the domains of events quantified over are similarly divided between possible and actual individuals.

Montague (1974a, 1974b) has pointed to (134) and Hazen (1976) to (135) as examples of quantifying over possibilia:

(134) There was a man whom no one remembers (Montague 1974a,b)

(135) All the buildings the zoning board has prevented from being built would have been monstrous (Hazen 1976)

In general, possible objects may have possible, non-actual parts. To pursue

the similarity with the individual events of (132), we consider the special case of quantifying over possible objects that are all made from actual, existing atoms. This is to be done by constructing an appropriate context for Hazen's (135).

Suppose for simplicity that buildings are constructed modularly from whole rooms. Also assume that the zoning board's ruling, alluded to in (135), was against some existing and defective construction units-- a particular warehouse full of modular rooms. Just like the atomic events of (132), these rooms are atomic objects. The individual buildings prevented by the zoning board correspond to combinations of the atoms.³² In this situation, (135) would be false if there is any combination of rooms from that warehouse (in any arrangement, see n. 32) that would not be monstrous. Thus the domain for the quantifier all the buildings the zoning board has prevented from being built must be closed under combinations of the atoms.

Now let us consider a situation, to evaluate (136), in which, contrary to the zoning board's ruling, buildings have been constructed out of the defective rooms in that warehouse.

(136) All the illegal buildings are six stories tall

It is certain that not every combination of rooms corresponds to one of the constructed buildings. Otherwise, the same room would have to appear in

32. Of course, for any given combination, different buildings are also obtained by rearranging the same atoms. There is no sense in which the atoms of an individual event can be rearranged, but this lapse in the analogy is not relevant, as will become clear shortly. The example below of quantifying over bunches of leaves is more like events in this respect. Although the leaves of a bunch can be rearranged, a new bunch is not obtained.

different locations. Sentence (136) has an interpretation that is true if every one of the constructed buildings is six stories tall. The domain of the quantifier all the illegal buildings thus includes only the constructed buildings. Note that if the domain included all combinations of rooms, (136) could not have a true interpretation, for some combinations of rooms are surely not six stories tall. In this context, the individuals are actual; the combinations of atoms that are quantified over are simply those that correspond to existing individuals.

Another example for the comparison of possible and actual individuals is (137), said while standing before a tree densely covered with leaves:

(137) All the bunches of leaves larger than three are allergenic

In this example, the individuals quantified over are bunches of leaves, and the atoms are leaves on the tree. The truth of (137) depends on every combination of leaves, any one of which falsifies (137) if it contains more than three leaves and fails to be allergenic. Among the possible bunches in the domain of the quantifier are those which could not exist at the same time if the leaves on the tree were actually segregated. Incompatible bunches require at least one leaf to be in different locations at the same time.

Compare now a context for (138) in which the fallen leaves of the allergenic tree have been raked up into several bunches scattered on the lawn:

(138) All the bunches of leaves (on the lawn) are allergenic

Assuming that (137) still characterizes the allergen, (138) is true if each of the bunches one sees on the lawn contains more than three leaves. The

sentence is not falsified by the one-, two- or three- leafed bunches that can be created from the actual bunches lying there. The domain of the quantifier all the bunches of leaves (on the lawn) is thus not closed under combinations of the atoms. Note that the domain of actual bunches is essentially a partition of the atoms on the lawn, since no leaf is in two places at once. A domain of actual individuals observed at a given moment will always have the property that it attributes to none of its atoms more than one location. This property holds at every instant even of stuff in constant flux, like the bits of glass, the atoms, constantly regrouping in a kaleidoscope to form new clusters, the individuals.

For the argument of subsequent sections in favor of event logic, two points about individuals, events in particular, will be crucial, namely that there are domains of individuals not closed under recombinations of their atoms and that there are interpretations for sentences in which quantification is over such domains. We will not need to rely on any particular method of quantifying over possible and actual individuals; however, it may be helpful to mention two different approaches to quantifying over possibles and actuals.

Montague (1974a,b) proposes that a predicate E(x), which attributes existence, picks out the actual individuals from a larger domain that includes all possible individuals. Thus, quantifier expressions such as "all the illegal buildings" and "all the bunches of leaves (on the lawn) are ambiguous between the two interpretations in (139) and (140). (139) contains quantifiers over possible individuals, and (140) contains quantifiers over actual individuals:

- (139) a. (possibles) [Ax: illegal building(x)]
- b. (possibles) [Ax: bunch of leaves (on the lawn)(x)]
- (140) a. (actuals) [Ax: illegal building(x) & E(x)]
- b. (actuals) [Ax: bunch of leaves (on the lawn)(x) & E(x)]

When the quantifier in (136), "all the illegal buildings", is interpreted as in (140a) its domain includes just the constructed buildings, since only these exist. Similarly, when (138)'s quantifier is interpreted according to (140b), it quantifies only over the bunches on the lawn, since the other bunches one might form from these same leaves do not exist.

An alternative approach, more in line with Hazen's (1976) discussion of modal logic, relies on the property that at any moment a domain of actual individuals attributes to none of its atoms more than one location. Define a reification to be any domain of individuals that has this property. It will more or less³³ partition the atoms. For examples (135) and (136), any way in which one could actually assemble all the rooms from the warehouse into buildings is a reification. For examples (137) and (138), each reification is a different way of actually segregating the leaves of the tree into bunches. On this approach, quantifying over possible individuals involves a modal operator; quantifiers not within the scope of the modal operator have a domain of actual individuals. Thus, "all the illegal buildings are monstrous" and "all the bunches of leaves are allergenic" are ambiguous between the interpretations in (141) and (142). The modal operator R should

33. More or less, because of cases such as two buildings that share a connecting corridor. The atomic rooms forming the corridor belong to both buildings. Note that the requirement that no atom occupy more than one location is still observed--hence, this property is the one defining reifications.

mean "in any reification."

- (141) a. (possibles) $R[[Ax: \text{illegal building}(x)] \text{ is monstrous}(x)]$
 b. (possibles) $R[[Ax: \text{bunch of leaves}(x)] \text{ is allergenic}(x)]$
- (142) a. (actuals) $[Ax: \text{illegal building}(x)] \text{ is monstrous}(x)$
 b. (actuals) $[Ax: \text{bunch of leaves}(x)] \text{ is allergenic}(x)$

There is always an implicit modal operator whenever a sentence is understood to be about possible individuals. The interpretations of (141) are paraphrased by "in any way there could be illegal buildings, all of them are monstrous" and "in any way there could be bunches of leaves, all of them are allergenic."

We return now to events. Whatever the method of quantifying over possible and actual individuals, events are like other individuals. Quantification over events also distinguishes between the possible and the actual. We construct appropriate contexts, first illustrating a domain of possible events.

Suppose that stalls for an abbatoir are manufactured so that each holds one hog at a time. This one-on-one relationship between stalls and hogs has for a consequence the event-dependent interpretations of the sentences in (143):

- (143) One hog (can fit/ fits) into one stall at a time
 One stall (can be/is) filled up with one hog at a time
- Two hogs (can) fit into two stalls at the same time...
 Two stalls (can be/are) filled up with two hogs at the same time
- n hogs (can) fit into n stalls at the same time
 n stalls (can be/are) filled up with n hogs at the same time

The event-dependent interpretation is paraphrased by (144):

(144) Whenever there is a fitting of hogs into n stalls at the same time,
 n hogs fit into them.

Whenever there is a filling up of stalls by n hogs at the same time,
 n stalls are filled up with them.

For any given herd of hogs and available stalls, a sentence in (143) could be falsified by any conceivable combination of the hogs and stalls. Thus, the last sentence is falsified if one can find any n among the given stalls which can be filled up with other than n of the hogs.

In the preceding example, the possible events quantified over do not combine already existing atomic events. They are only what could possibly be done to any combination of possible participants among the given hogs and stalls. We can also provide a context of already existing atomic events, combinations of which make up the possible events. Suppose that hogs have in fact been slaughtered in stalls. We can consider as an atomic event the period before slaughter when a single stall was filled up with however many³⁴ hogs it accomodated. These atomic events exist since hogs have been slaughtered in stalls.

Recall that we have in mind the event-dependent interpretations of (143) which follow from the one-on-one relationship between stalls and hogs. These interpretations are meant to be general laws that hold in arbitrary situations. What in the situation in which hogs have been slaughtered would disconfirm these interpretations? This interpretation of the last sentence of (143) would be falsified if any combination of n atomic events, among the existing ones defined above, took place at the same time and involved other

34. Since slaughter ensues, the stall is not empty.

than n hogs. Thus, the domain of possible events includes recombinations of the atoms.

To compare a domain of actual events, assume that one is speaking of the operations of a particular abbatoir which follows a particular schedule, slaughtering hogs in a succession of sessions. The actual events can be understood to correspond to the sessions, so that the event-dependent interpretation of (145) is true if at each session twenty-five hogs fit into stalls:

(145) Twenty-five hogs fit into stalls

"Whenever there is a fitting of hogs into stalls, twenty-five hogs fit into them"

Note that this interpretation is not falsified because one can find a session in which some proper subset of the stalls used did not hold twenty-five hogs. Every event in the domain must include all the stalls used in some session and all the hogs held in that session. Although proper parts of these events would also satisfy the predicate fit into stalls(e), they are not individuals in the understood sequence of events.³⁵ Thus in some contexts there can be a domain of individual events that is not closed under combinations of its atoms.

As remarked earlier, what will be crucial in future sections is that a sentence can be interpreted with respect to a particular domain of individual

35. Explicitly adding "in a session" to (145),

Twenty-five hogs fit into stalls in a session

"Whenever there is a fitting of hogs into stalls in a session...",

will not eliminate the unwanted proper parts, since these too were all in some session or another.

events that excludes alternative combinations of their parts. Events, as we have seen, are no different from other individuals in allowing this or in allowing quantification over all possibles.

The domains of events on which we will rely are contextually-specified proper subsets of the possible events that could be obtained from alternative combinations of their parts. It is sufficient for us that the domains specified in these examples are judged acceptable; but, as part of a larger interest in events, one could ask whether any proper subset of the possible events can be a contextually-specified domain of actual events.

All the domains of events contrived in this work have the property, mentioned on p. 76, that identifies reifications among domains of individuals. No atomic events, no event-stuff, is assigned more than one location. Since events are thought of as discrete and different events have different spatio-temporal locations³⁶, a reification of events will partition whatever event parts there are. It may be a general constraint on how one thinks about actual events that every domain must be a reification. I know of no counterexample.

If one can define reifications of events, quantifying over actual and possible events is open to both of the treatments seen earlier for quantifying over actual and possible objects. Thus the event-dependent interpretations of (145), which quantify over actual and possible events may be treated by either (146) or (147).

36. That is they differ on at least one dimension or the other. Thus, distinct events in the same place occur at different times, and distinct events at the same time occur in different places.

(146)(possibles) [Ee fit(e): into(e, stalls)] INFL(e, twenty-five hogs)
 (actuals) [Ee fit(e): into(e, stalls) & E(e)] INFL(e, twenty-five hogs)

(147)(possibles) R[Ee fit(e): into(e, stalls)] INFL(e, twenty-five hogs)
 (actuals) [Ee fit(e): into(e, stalls)] INFL(e, twenty-five hogs)

Other plausible constraints on domains of actual events can be anticipated. Recall the earlier figure of ten atomic events, each of which was a loading of one truck by several truckers:

(132)

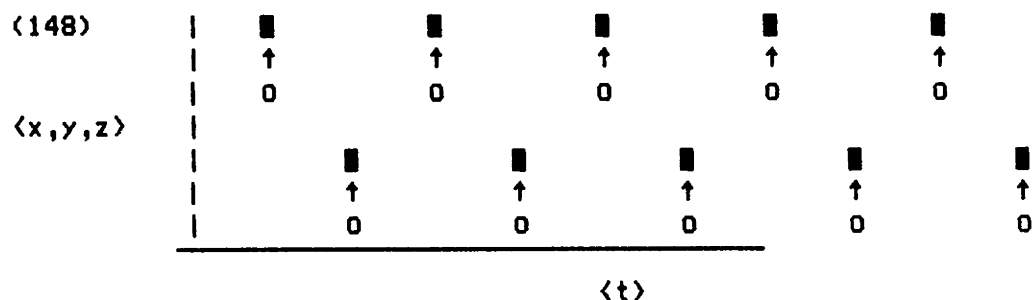
■	■	■	■	■	■	■	■	■	■
↑	↑	↑	↑	↑	↑	↑	↑	↑	↑
0	0	0	0	0	0	0	0	0	0

Any combination of these atoms is a possible event denoted by the predicate load(ed) up one or more trucks(e). There are many reifications of these atoms that in some context or another might be taken to be the actual events denoted by load(ed) up one or more trucks(e). In one context, for example, all ten atoms might be part of one such event, or in another context, each atom might be a distinct actual event. As remarked earlier, a variety of reifications will always be available whatever scale locates the atomic events of (132) in time and space.

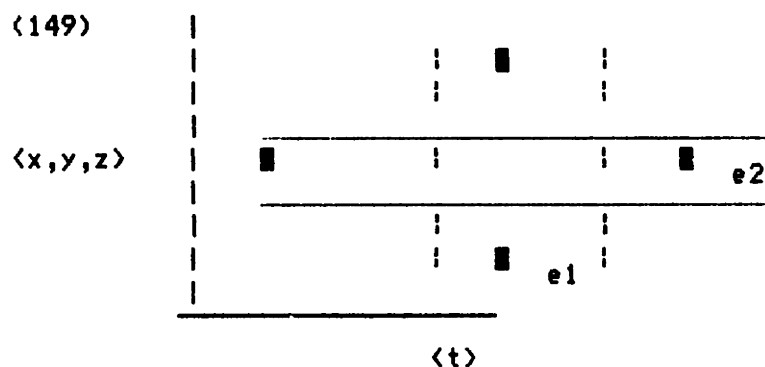
Suppose now that (132) is a temporal sequence. It seems unlikely that there could be a domain of actual events that partitions the odd atoms into one individual event and the even atoms into another, although such a domain would be a reification. If it is truly impossible, there are other constraints that affect our conception of a domain of actual events. What this case suggests is that an actual event is thought of as a continuous region in which its constituent activities take place and that the actual events in a particular domain do not overlap.

One must be careful in ruling out overlap. As presented, (132) is to be

thought of as a time line, suppressing location in space. Suppose this dimension were made explicit, as in (148), revealing that the odd atomic events were in one place and the even atomic events in another:



Then, it seems possible to consider their partition into two actual events according to their location in space. The events still overlap in time; however, they do occupy continuous regions of space-time that do not overlap. (149) is an example of unacceptable overlap in two dimensions.



Four atomic events are partitioned into two actual events. The other partitions yield acceptable domains.

One would need to have an especially robust mental picture of events to accomodate these intuitions if they survive scrutiny. The mental context for interpreting a sentence would include not just a domain of actual events but also a particular kind of space on which they are located-- temporal, spatial, or spatio-temporal projections. Whether the constraint against

overlap or other constraints govern our cognition of events will of course be left open here. For the logic of plurality, it suffices that events exist and that contextually-dependent domains of events are not closed under any operation recombining their parts. Events in this respect are just like other individuals.

3.6

It may be helpful in comparing event logic and set-denotative logic to try to separate differences of logical form from differences of interpretation. A particular system of interpretation may be realized by different systems of logical form, and our eventual interest is to find the correct logical form for event logic.

I will illustrate what I mean by different logical forms for the same system of interpretation with an example from the literature, Allen Hazen's (1976) "Expressive Completeness in Modal Language."³⁷ The sentences expressed within the various systems of logical form that he considers are all interpreted with respect to possible worlds and their individuals. In particular, he fixes that interpretation quantifies over worlds. It is a question of logical form whether this quantification over worlds is realized by either the modal language or the language with explicit variables for worlds, which follow.

37. Kamp (1968) investigates a similar problem.

The modal language represents the quantification over worlds with modal operators L and M for which Hazen gives the conditions in (150):

(150) "A necessitate $[L\phi]$ is true at a world and on an assignment if and only if its matrix $[\phi]$ is true on that assignment at every world."

"A possibilitate $[M\phi]$ is true at a world and on an assignment if and only if there is some world at which its matrix $[\phi]$ is true on that assignment."

The explicitly quantificational language contains universal $\langle A_w \rangle$ and existential $\langle E_w \rangle$ quantifiers that bind variables whose values are worlds. In addition, this language contains a relation " $I_x w$ " that is true of an individual and a world just in case that individual is in that world.

Although both of these languages quantify over possible worlds, their expressive power is different. Hazen shows that everything in the modal language has a translation into the explicitly quantificational one—for example, " $L \text{ Ex } R(x)$ " in the modal language translates into " $A_w \text{ Ex } I_x w \ \& \ R'xw$ ", where " $R'xw$ " means that x is R at w --but some things expressible in the quantificational language are not expressible in the modal. One example, paraphrased by "there is a world that has a common member with every world", is expressed in the quantificational language by " $E_w A_w \text{ Ex } \langle I_x w \ \& \ I_x w' \rangle$." The modal language cannot translate the constituent " $\text{Ex} \langle I_x w \ \& \ I_x w' \rangle$ " which expresses a relation that holds between worlds.

In contrast to what I have called a difference of logical form between the modal and quantificational languages, set-denotative logic and event logic also differ in interpretation. There is no translation between them. As we have seen, their analyses of plurals assume different ontologies, that is, events as opposed to sets of individuals, and a different view of the

structure of polyadic predicates in natural language (cf. (38) and (41)). The overall plan of the following chapters is to first establish the event logic's interpretations and then to defend the more syntactic aspects of its system of logical form.

Chapter 4

Evidence for events

Recall the general characteristics of event logic. There are domains of individual objects and domains of individual events with the properties discussed in the preceding section. The only set-like individuals are events, which "contain" their participants. There are no sets, nor sums, nor classes otherwise defined of individual objects.

Recall also that the main "trick" behind event logic uses events to mediate the expression of relations among pluralities.

(31) Three agents sold twenty-five buildings to two investors.

(32) Ee [e was a selling & e's sellers were three agents &
e's seltees were two investors & e's sold were twenty-five buildings.]

Thus, the fact that the three agent's selling was of the twenty-five buildings and to the two investors is known from the participation of agents, buildings and investors in the same event. In event logic, there are no atomic relations that denote n-tuples of sets.

The appearance of quantifying over sets of individual objects is entirely derived from quantifying over the events in which individual objects participate. Plural NPs are predicates true or false of an event's participants, as suggested by the paraphrase in (32) and discussed in sec.

4.1

The analysis of plurality in set-denotative logic is different in a number of respects. Plurals are quantifiers over a domain of sets of individuals. These sets are accorded the same ontological status as individual objects. They are just individual objects occurring together in some sense. In fact, in some versions of set-denotative logic, e.g., Scha (1981), individual objects are identified with singleton sets rather than exist as members of a distinct type or sort.

Set-denotative logic also maintains, agreeing with standard assumption 0.1., the polyadicity of a verb. Thus, a verb in n places, occupied by n plurals expresses an atomic relation that denotes an n-tuple of sets.

Recall the following clauses according to which the plural quantifiers in set-denotative logic are interpreted³⁸:

38. A non-increasing quantifier establishes an upper bound on the extension of the predicate: Φ is true of C and no others. Hence, the clauses in (16) (cf. ((152)) must take in everything that is Φ. Some of the non-increasing quantifiers, those which are here called non-decreasing, establish at the same time a lower bound on the extension of the predicate, requiring at least some non-empty C to be Φ. Decreasing quantifiers allow the extension of the predicate to be empty. few critics and none of the books are examples of decreasing quantifiers, and exactly ten critics is a non-increasing, non-decreasing quantifier. Increasing quantifiers, as the existential quantification in (15) (cf. (151)) shows, establish a lower bound but impose no upper bound. Examples are ten critics, the boys and some books.

- (i) NP is non-increasing if it establishes an upper bound
 NP is increasing if it does not establish an upper bound

(15) Increasing quantifiers.

- a. (undivided reference to a denotatum) "[Q N'] $\phi(x)$ " is true iff for some (class) c , c is [Q N']-many, and " $\phi(c)$ " is true.
- b. (divided reference to denotata) "[Q N'] $\phi(x)$ " is true iff for some (classes) c_1, \dots, c_k, \dots , the union of c_1, \dots, c_k, \dots is [Q N']-many and " $\phi(c_1)$ " is true...and " $\phi(c_k)$ " is true....

(16) Non-increasing quantifiers.

- a. (event-dependent) "[Q N'] $\phi(x)$ " is true iff every (class) c such that " $\phi(c)$ " is true is [Q N']-many.
- b. (non-event-dependent) "[Q N'] $\phi(x)$ " is true iff the union of all classes c such that " $\phi(c)$ " is true is [Q N']-many.

The interpretations obtained from these clauses are summarized in (151) and (152), where \underline{c} and \underline{s} are variables over sets, and \underline{x} is a variable over individual objects:

(151) Increasing quantifiers.

- a. (undivided reference) $\text{Er} ([Q N'](\underline{r}) \ \& \ \phi(\underline{r}))$
- b. (divided reference) $\text{Es} ([Q N'](\underline{s}) \ \& \ \text{Ax}(\underline{x} \in \underline{s} \rightarrow \text{Er}(\underline{x} \in \underline{r} \ \& \ \underline{r} \subseteq \underline{s} \ \& \ \phi(\underline{r}))))$

(152) Non-increasing quantifiers.

- a. (event-dependent) $\text{Ar} (\phi(\underline{r}) \rightarrow [Q N'](\underline{r}))$
- b. (non-ev.-dep.) $\text{Es} (([Q N'](\underline{s}) \ \& \ \text{Ar}(\phi(\underline{r}) \rightarrow \underline{r} \subseteq \underline{s})) \ \& \ \text{At}((\text{Ar}(\phi(\underline{r}) \rightarrow \underline{r} \subseteq \underline{t}) \rightarrow \underline{s} \subseteq \underline{t})))$ ³⁹

NP is non-decreasing if it establishes a lower bound
 NP is decreasing if it does not establish a lower bound

No NP is both increasing and decreasing.

39. The last conjunct, " $\text{At}(\dots)$ ", guarantees that \underline{s} is the least upper bound on the extension of the predicate. This clause is otiose in the interpretation of decreasing quantifiers; it is necessary for non-increasing, non-decreasing quantifiers such as exactly ten critics.

(i) Exactly ten critics left

Otherwise, there could be a set \underline{s}' , satisfying the non-event-dependent truth conditions for (i), which contained all critics that left and contained exactly ten critics, although some of its member critics did not leave.

(16b), because it is stated in terms of the union of just those sets that satisfy the predicate, will not count miscellaneous objects.

Note that all and only the interpretations of non-increasing quantifiers ((152)) include a universal quantifier over sets. Increasing quantifiers ((151)) have only existential force.

4.2

The first two arguments and their supporting remarks are divided between sec. 4.2-4.5 and sec. 4.6-4.10. These arguments oppose the simple ontology of the set-denotative logic, which uses in its analysis of plurals a domain containing sets but no domain of events. The first two arguments show that one cannot freely quantify over a domain that comprehends all sets of individual objects. Quantification over sets, if it exists at all, must be restricted by a relationship to events which these sections will establish. We will see that event logic, without further modification, respects the required restriction simply by quantifying over events instead of sets. An extension of the set-denotative logic is proposed which also has the potential to meet the required restriction by adding on a domain of events alongside the domain of sets. This extension is the subject of later sections.

We first consider interpretations assigned by set-denotative logic which are unacceptable if the domain of sets quantified over includes every set of individuals. Since our concern is that the domain of sets may be too large, it is not surprising that the relevant interpretations involve non-increasing quantifiers, which, as noted above ((152)), quantify over every set in the domain.

The relevant interpretations are all those obtained from the clauses in (15) and (16) that conform to (153):

(153) NP_1 non-increasing $(NP^{increasing})^* NP_2$ decreasing ♦

That is, in any of these interpretations the first quantifier interpreted, the one assigned the widest scope, is non-increasing, and it may be interpreted either by (16a) as event-dependent or by (16b) as non-event-dependent. This quantifier, NP_1 , is then followed by any number of increasing quantifiers, which are followed by a decreasing quantifier NP_2 . NP_2 may be interpreted by either clause of (16). As long as the scope assignment of (153) is respected, we are interested in interpreting the quantifiers by all combinations obtainable from (15) and (16).

The sentences in (154)–(157) are simple examples where the number of increasing quantifiers (NP^*) in the relevant interpretations is zero:

(154) a. Few critics bought few good books
b. Only a few critics bought fewer than ten good books
c. Not more than ten critics bought none of the books
d. Exactly ten critics bought not all of the good books

(155) a. Few students fit into few phone booths
b. Only a few students fit into fewer than ten phone booths
c. Not more than ten students fit into none of the phone booths
d. Exactly ten students fit into not all of the phone booths

(156) a. Few delegates agree (with each other) on few important issues
b. Only a few delegates agree (with each other) on fewer than ten important issues
c. Not more than ten delegates agree (with each other) on none of the important issues
d. Exactly ten delegates agree (with each other) on not all of the important issues

(157) a. Few unionists gathered at few rallies
b. Only a few unionists gathered at fewer than ten rallies
c. Not more than ten unionists gathered at none of the rallies
d. Exactly ten unionists gathered at not all of the rallies

It will now be shown that the interpretations conforming to (153) attribute to these sentences truth conditions they in fact do not have, from which we

conclude that such interpretations should not be assigned. The incorrect assignment of these interpretations to sentences like (154)–(156) is an immediate effect of set-denotative logic, following from its basic assumptions: (0.1) polyadic predicates are atomic relations, plurals are quantifiers according to clauses (15) and (16) (see 0.2.), and the domain of quantification includes any set of individual objects. ⁴⁰

We demonstrate the unacceptability of these interpretations for the examples (154a) and (154d), which illustrate the two cases of non-increasing NP_1 : decreasing "few critics" and non-decreasing "exactly ten critics". The unacceptability of these interpretations can be demonstrated for other examples in the same way.

In set-denotative logic, the domain of quantification includes any set of individual objects there are (except the empty set). We allow that the existing or relevant individual objects may depend on the context for the sentence. Thus, "few critics" in (154a) may be intended to mean few of the critics at hand. Such dependence on context, often called domain selection, can be thought of in terms of a tacit restriction on the quantifier, as in the explicit "few relevant critics", which is itself contextually-dependent. Now relative to any context, the domain of quantification in set-denotative

40. (153) does not specify the relative position of NP_1 , NF^* and NP_2 in the surface syntax. Thus, some relevant interpretations will involve "inverted" scope assignments: in the surface syntax, NP_2 may, for example, be superior to NP_1 . I do not rely on the existence of such cases. In all the interpretations discussed here, we let scope reflect syntactic superiority: in (154)–(156), NP_1 corresponds to the syntactic subject and NP_2 , to the object. Cases of "inverted" scope are included among the relevant interpretations because their assignment will result in the same kind of unacceptable truth conditions.

logic includes every subset, except the empty set, of relevant individual objects.⁴¹ In demonstrating the unacceptability of the set-denotative interpretations assigned to (154a) and (154d), we will let C stand for the set of all critics there are in a given context. C is of course the largest set of critics contained in any domain of quantification. As remarked earlier, the interpretations conforming to (153) involve universal quantifiers over sets. Using C as a particular instance of the sets quantified over will reveal an unacceptable implication of these interpretations.

In the first case NP_1 is a decreasing quantifier "few critics". We must consider both of its interpretations in set-denotative logic, as an event-dependent quantifier according to (16a) and as a non-event-dependent quantifier according to (16b). These interpretations are equivalent respectively to (157) and (158), which are instances of (152a) and (152b).⁴² The values of \underline{r} , \underline{s} and \underline{t} are sets:

(157) $\text{Ar } (\text{critics}(\underline{r}) \text{ bought few good books} \rightarrow \text{few critics}(\underline{r}))$

(158) $\text{Es } ((\text{few critics}(\underline{s}) \ \& \ \text{Ar}(\text{critics}(\underline{r}) \text{ bought few good books} \rightarrow \underline{r}\underline{C}\underline{s})) \ \& \ \text{At}((\text{Ar}(\text{critics}(\underline{r}) \text{ bought few good books} \rightarrow \underline{r}\underline{C}\underline{t}) \rightarrow \underline{s}\underline{C}\underline{t}))$

The event-dependent interpretation of (154a) is true according to set-denotative logic if and only if ((157)) every set (of critics) that

41. I.e., if A is the set of relevant individual objects, the domain of quantification is the power set of A minus the empty set. See Eberle (1970).

42. The argument concerning C is unchanged if the atomic predicate is "buy(x,y)" instead of "critics(x) buy good books(y)", just replace all occurrences of latter with the former. But, the simpler predicate will also allow a stronger result if C is everywhere replaced by U, the set of every one, critics and non-critics. That result is stated in a later footnote. See sec. 2.4.2.

bought few good books is few critics. Thus, any set (of critics) is either few critics or did not buy few good books:

(159) Ar (few critics(r) or not(critics(r)bought few good books))

The non-event-dependent interpretation imposes stronger conditions, which in fact entail the event-dependent interpretation. It is true according to set-denotative logic if and only if (158) the union of every set (of critics) that bought few good books is few books. Any one set (of critics) in the domain is either a subset of a particular set of few critics and is a fortiori itself few critics or did not buy few good books:

(160) Es ((few critics(s) & Ar(rCs or not(critics(r)bought few good books)) & At((Ar(critics(r)bought few good books → rCt) → sCt))

Similar remarks pertain to the second case where NP_i is "exactly ten critics" in (154d). We must consider both of its interpretations in set-denotative logic, as an event-dependent quantifier according to (16a) and as a non-event-dependent quantifier according to (16b). These interpretations are equivalent respectively to (161) and (162), which are instances of (152a) and (152b). The values of r, s and t are sets:

(161) Ar (critics(r) bought not all of the good books → exactly ten critics(r))

(162) Es ((exactly ten critics(s) & Ar(critics(r) bought not all of the good books → rCs)) & At((Ar(critics(r) bought not all of the good books → rCt) → sCt))

The event-dependent interpretation of (154d) is true according to set-denotative logic if and only if ((161)) every set (of critics) that bought not all of the good books is exactly ten critics. Thus, any set (of critics) is either ten critics or did not buy not all of the good books:

(163) Ar(exactly ten critics(r) or not(critics(r) bought not all of the good book

The non-event-dependent interpretation is true according to set-denotative logic if and only if (162) the union of every set (of critics) that bought not all of the good books is exactly ten books. Any one set (of critics) in the domain is either a subset of a particular set of ten critics or did not buy not all of the good books:

(164) $Es(\langle \text{exactly ten critics}(s) \rangle \ \& \ \text{Ar}(\text{rCs or } \underline{\text{not}}(\text{critics}(r) \text{ bought not all of the good books})) \ \& \ \text{At}(\langle \text{Ar}(\text{critics}(r) \text{ bought not all of the good books} \rightarrow \text{rCt}) \rightarrow \text{sCt}))$

The expressions last seen representing the truth conditions of event-dependent and non-event-dependent NP_1 contain in a disjunct the decreasing quantifiers corresponding to NP_2 in (153), either "few good books" or "not all of the good books":

(159), (160) ...or not(critics(r) bought few good books)...

(163), (164) ...or not(critics(r) bought not all of the good books)...

We must consider both interpretations of the decreasing NP_2 , as event-dependent and as non-event dependent. The values of u, v and w are also sets:

(165) from (159) and (160)

a. (event-dep.) ...or not[Au(critics(r) bought good books(u) \rightarrow few good books(u))]

b. (non-event dependent):

...or not[Ev((few good books(v) $\&$ Au(critics(r) bought good books(u) \rightarrow uCv)) $\&$ Aw((Au(critics(r) bought good books(u) \rightarrow uCw) \rightarrow vCw)))]...

(166) from (163) and (164)

a. (event-dependent):

...or not[Au(critics(r) bought good books(u) \rightarrow not all of the good books(u))]

b. (non-event dependent): ...

or not[Ev((not all of the good books(v) $\&$ Au(critics(r) bought good books(u) \rightarrow uCv) $\&$ Aw((Au(critics(r) bought good books(u) \rightarrow uCw) \rightarrow vCw)))]...

Pushing through the negation these are equivalent to:

(167) from (159) and (160)

a. (ev.-dep.) ...or $\text{Eu}(\text{critics}(r)\text{bought good books}(u) \ \& \ \text{not}(\text{few good books}(u)))$...

b. (non-event dependent):

...or $\text{Av}(\text{not}(\text{few good books}(v)) \text{ or } \text{Eu}(\text{critics}(r)\text{bought good books}(u) \ \& \ \text{not}(u\text{Cv})) \text{ or } \text{Ew}(\text{Au}(\text{critics}(r)\text{bought good books}(u) \rightarrow u\text{Cw}) \ \& \ \text{not}(v\text{Cw})))$...

(168) from (163) and (164)

a. (event-dependent):

...or $\text{Eu}(\text{critics}(r)\text{bought good books}(u) \ \& \ \text{not}(\text{not all of the good books}(u)))$...

b. (non-event dependent)...or $\text{Av}(\text{not}(\text{not all of the good books}(v)) \text{ or } \text{Eu}(\text{critics}(r)\text{bought good books}(u) \ \& \ \text{not}(u\text{Cv}))) \text{ or } \text{Ew}(\text{Au}(\text{critics}(r)\text{bought good books}(u) \rightarrow u\text{Cw}) \ \& \ \text{not}(v\text{Cw})))$...

Recall that we are to use C, the set of all critics (in whatever context) as a particular instance of the sets quantified over to reveal unacceptable implications of the set-denotative interpretations of (154a) and (154d) which conform to (153). (154a) under any combination of (159) or (160) with (167a) or (167b) will require C to meet at least the condition in (169), where x is a variable over individual objects:

(169) $\text{few critics}(C) \text{ or } \text{Eu}(\text{not}(\text{few good books}(u)) \ \& \ \text{Ax}(x \in u \rightarrow \text{Ev}(x \in v \ \& \ v\text{Cu} \ \& \ \text{critics}(C)\text{bought good books}(v))))$

For if C is not few critics it is also not a subset of few critics. The event-dependent interpretation and the non-event dependent interpretation of (154a) then require that C not have bought few good books. That is, C bought many good books, whether "few good books" is interpreted as event-dependent or not. If "few good books" is interpreted as event-dependent ((167a)), there is some set of not few good books that C bought. If the quantifier is interpreted as non-event-dependent ((167b)), then there is some set of not few books whose members can be divided up among sets each of which C bought. Of course every set of not few books that satisfies the first interpretation will also satisfy the second. Such a set is just the special case where the members of a set of not few books all occur in one set that C bought. Thus,

(169) represents the weakest condition on C required by all the set-denotative interpretations.⁴³

Similar remarks show that (154d) under any combination of (163) or (164) with (168a) or (168b) requires C to meet at least the condition in (170):

(170) exactly ten critics(C) or $\text{Eu}(\text{not}(\text{not all of the good books}(u)) \ \& \ \text{Ax}(x \in u \rightarrow \text{Ev}(x \in v \ \& \ v \subseteq u \ \& \ \text{critics}(C) \text{bought good books}(v))))$

It should be pointed out that the non-event-dependent interpretation of "exactly ten critics" would not imply (170) if C were any arbitrary set⁴⁴; but, as the set of all critics, C cannot be less than ten critics if the non-event-dependent interpretation is true, since there must be exactly ten critics buying not all of the good books. If C is more than ten critics, then this interpretation requires that C not buy not all of the good books, as in (170).

What is implied about C by the various set-denotative interpretations of (154a) and (154d) can be paraphrased as follows:

43. In (167b), some sets \underline{u} will satisfy the second disjunct and not the first. Any such set is simply not a least upper bound on the predicate "bought(C,u)" (see n. 39). There is however a least upper bound, a set failing to satisfy the second disjunct. Such a set \underline{u} must satisfy the first disjunct, itself a disjunction. Since all sets that C bought are subsets of \underline{u} , because it is an upper bound, \underline{u} must be not few good books, satisfying the first clause in the remaining disjunction. Since, \underline{u} is the least upper bound on the predicate, every one of its member must belong to some set that C bought, as required by (169).

44. For an arbitrary set S, the non-event dependent interpretation implies (i):

(i) ≤ ten critics(S) or $\text{Eu}(\text{not}(\text{not all of the good books}(u)) \ \& \ \text{Ax}(x \in u \rightarrow \text{Ev}(x \in v \ \& \ v \subseteq u \ \& \ \text{critics}(S) \text{bought good books}(v))))$

(169) would still be implied by all of (154a)'s interpretations if C were an arbitrary set.

(171)((154a) implies that) There are few critics (in the given context),
or all the critics bought many good books

(172)((154d) implies that) There are exactly ten critics (in the given context),
or all the critics bought all the good books

The plurals of the second conjuncts must not be read distributively, since
they paraphrase a relation between sets. (173) and (174) are less ambiguous
paraphrases:

(173)((154a) implies that) There are few critics (in the given context),
or all the critics were involved in buying many good books⁴⁵

(174)((154d) implies that) There are exactly ten critics (in the given context),
or all the critics were involved in buying all of the good books^{46,47}

The peculiarity of these interpretations in set-denotative logic is that
whenever the context contains more critics than the quantity mentioned in
NP₁, not one of them escapes some involvement in buying books. This
peculiarity characterizes the set-denotative interpretations conforming to
(153) for all the examples in (154)-(157). Thus, these interpretations of
(157a) require that there are few unionists or else they all gathered at not
few rallies. But, no actual interpretation of the examples in (154)-(157)
imposes such truth conditions.

45. As permitted by (169), the many books bought may be distributed among
several instances of buying each of which all the critics were involved in.

46. As permitted by (170), all of the good books may be distributed among
several instances of buying each of which all the critics were involved in.

47. If the argument is modified according to n. 42, what is implied about U
is:

(173')((154a) implies that) There are few critics (in the given context),
or everyone was involved in buying many good books

(174')((154d) implies that) There are exactly ten critics (in the given context)
or everyone was involved in buying all of the good books

Recall that the claim was that all interpretations in set-denotative logic that conform to (153) have unacceptable truth conditions.

(153) $NP_1^{\text{non-increasing}} (NP^{\text{increasing}})^* NP_2^{\text{decreasing}} \diamond$

We provide now a schema that shows an unacceptable implication in the general case when there are one or more increasing quantifiers:

(175) $NP_1^{\text{non-increasing}} NP_{\text{incr.}}^1 \dots NP_{\text{incr.}}^k NP_2^{\text{decreasing}} \diamond$

These conditions are obtained by reasoning as above. It is left to the reader to verify the following.

Assuming that $NP_1^{\text{non-increasing}}$ is "[Q N']", let the set C be all N' (in the given context). Then, all interpretations of the quantifiers, event-dependent or not, which respect the assignment of scope in (175), require C to meet the following condition:

(176) $NP_1^{\text{non-incr.}}(C)$ or
 $\text{not}[Es^1 \dots Es^k (NP_{\text{incr.}}^1(s^1) \& \dots \& NP_{\text{incr.}}^k(s^k) \& [NP_2^{\text{decreasing}}(C, s^1, \dots, s^k)])]$

This is equivalent to:

(177) $NP_1^{\text{non-incr.}}(C)$ or
 $As^1 \dots As^k ((NP_{\text{incr.}}^1(s^1) \& \dots \& NP_{\text{incr.}}^k(s^k)) \rightarrow \text{not}[[NP_2^{\text{decreasing}}(C, s^1, \dots, s^k)])]$

Resorting to paraphrase, we have:

(178) There are [G N'] (= $NP_1^{\text{non-incr.}}$), or
 for every k sets of $NP_{\text{incr.}}^1, \dots$ and $NP_{\text{incr.}}^k$,
 all the N' were involved in \diamond -ing not $NP_2^{\text{decr.}}$.

4.3

It may be helpful to compare the unacceptable interpretations assigned by set-denotative logic with acceptable interpretations.

4.3.1

Consider first those interpretations in which the scope indicated by (153) is assigned to standard quantifiers, which bind variables whose values are individual objects:

(179) [Few x : critic(x)] [Few y : good book(y)] x bought y

(180) [Exactly ten x : unionist(x)] [not all y : rally(y)] x gathered at y

When an arbitrary set is more than few critics, (179) requires that at least one individual critic in that set does not satisfy the formula within the scope of NP_1 , viz., "[Few y : good book(y)] x bought y ". That is, at least one of them did not buy few good books; he bought many. This is of course correct. Note that it does not commit the totality of critics in that set to book buying. Some of them (although no more than few of them) may have had nothing to do with buying books.

Similarly, when an arbitrary set is more than ten unionists, (180) requires that at least all but ten of the unionists in that set each fails to satisfy "[not all y : rally(y)] x gathered at y ". That is, each of all but ten of them was in gatherings at all the rallies. Again, it is possible for as many as ten of the remaining unionists to have attended none of the rallies.

As we have seen in the set-denotative interpretations, when an arbitrary set, such as the set of all critics or the set of all unionists, is more than NP_1 , it itself--rather than some of its members--is required to not satisfy the formula within the scope of NP_1 . They, the members of that set, must have bought many good books, in the case of (179), and they must have gathered at all the rallies, in the case of (180). All the critics are committed to some involvement in book-buying, and all the unionists are committed to some involvement in gatherings at rallies.

4.3.2

It should not be mistakenly concluded from the discussion of sec. 4.2. that no interpretation of examples in (154)-(157) will ever impose conditions on maximal sets, analogous to C, which are all the N' in a given context⁴⁸.

To varying degrees of acceptability, these sentences admit a sum of plurals interpretation.⁴⁹ This is not one of the excluded interpretations conforming to (153), since, it should be recalled, none of the plurals is within the scope of another in a sum of plurals. This interpretation of (154a) means that few critics bought good books and few good books were bought by critics. Similarly, in the case of (154d), it means that exactly ten critics bought some of the good books and not all of the good books were bought by critics.

48. all the critics for (154), all the students for (155), all the delegates for (156), and all the unionists for (157)

49. It is somewhat marginal if the subject, NP_1 , is a decreasing quantifier, as in the much discussed nobody loves nobody with the meaning that nobody loves and nobody is loved. See May (1984).

In any context in which the maximal set C of all critics bought good books, the sum of plurals interpretations of (154a) and (154d) will require C to meet the conditions in (181) and (182) respectively:

(181) few critics(C) & bought few good books(C)

(182) exactly ten critics(C) & bought not all of the good books(C)

Note that in any context in which (181) is true, (169) is also true, although it was judged that (169) is not a valid implication of either the event-dependent or non-event-dependent interpretation of (154a). Similarly, (170), an unacceptable implication of any set-denotative interpretation of (154d) that conforms to (153), is true in any context in which (182) obtains. Nevertheless, the sum of plurals interpretation cannot be confounded with these others.

First, in any context in which a sum of plurals interpretation imposes on C one of the conditions in (181) and (182), it does not impose such a condition on any other set. As we have seen, the set-denotative interpretations conforming to (153) quantify over all the sets of individuals in a given context. Second, there are situations of which the set-denotative interpretations conforming to (153) are true but not the sum of plurals. Thus, these interpretations of (154a) are true, although the sum of plurals interpretation is false, if every critic bought every one of many good books. Since, there is no set of critics that bought few good books, each such set or all of them taken together are few critics, verifying the interpretations conforming to (153). The sum of plurals interpretation is false because many good books were bought by critics.

4.4 Comparison with event logic

(183)-(185) represent the event logic for event-dependent and non-event-dependent interpretations of (154a), (154d) and (157d). Recall that the values of e are events and the values of x are individual objects⁵⁰:

(183) a. (event-dep.) $[Ae: \text{buy few good books}(e)] [\text{few critics}(x)] x \in e$

b. (non-ev.-dep.) $[\text{few critics}(x)] [Ee: \text{buy few good books}(e)] x \in e$

(184) a. (event-dependent):

$[Ae: \text{buy not all of the good books}(e)] [\text{exactly ten critics}(x)] x \in e$

b. (non-event-dependent):

$[\text{exactly ten critics}(x)] [Ee: \text{buy not all of the good books}(e)] x \in e$

(185) a. (event-dependent):

$[Ae: \text{gather at not all of the rallies}(e)] [\text{exactly ten unionists}(x)] x \in e$

b. (non-event-dependent):

$[\text{exactly ten unionists}(x)] [Ee: \text{gather at not all of the rallies}(e)] x \in e$

In event logic, conditions on arbitrary sets are entirely derived from quantifying over events in which their members participated. In an event-dependent interpretation such as (183a), NP_1 "few critics" is a condition on an arbitrary set just in case the members of that set are the participants in an event of buying few good books. When an arbitrary set is more than few critics, (183a) requires only that there be in the given context no such event whose participants are the members of that set. Thus (183a) avoids the peculiarity of the set-denotative interpretations of

50. For explicitness, we retain the notation in which " \in " stands for "is involved in". See the discussion in sec. 3.3 in which logical forms without " \in " are adopted.

(154a), which, when an arbitrary set is more than few critics, require that its members were all involved in buying many books.

Similar remarks apply to the event logic for non-event-dependent interpretations, as in (183b). When an arbitrary set is more than few critics, (183b) requires that not all of its members participated in events of buying few good books. In particular, there is no one such event in which all of its members are the participants. But, (183b) does not imply that all the critics are involved in buying many books if there are more than few critics.

As we have seen, in event logic, the real objects of predication and quantification are events rather than sets. The quantity of a set is affected only in so far as its members are participants in events. It should be emphasized that we do not expect that every (non-empty) set of individual objects in a given context will correspond to an event. Suppose, for example, that all critics in the given context are divided among local book clubs. On different days of the week, a different club will go on an outing at which the members who are present buy books for the club. The events of this context are the outings. According to the event-logical (183), the event-dependent interpretation of (154a) is true in this context if and only if each of the outings at which few good books were bought involved few critics, and the non-event-dependent interpretation is true if and only if all such outings involved all together few critics. Now in this context the set of all critics does not correspond to an event, although every critic may have gone on some of the outings.

In other contexts, the set of all critics might have a corresponding

event. Consider a domain of events that includes all the outings of the local book clubs but also some book-buying outings of the national organization to which all locals and their members belong. One of the national outings may have been attended by all the critics. Only in such circumstances do the event-logical interpretations imply that all the critics, if they are not few, are involved in buying many good books. For all the critics attended a national outing, an event of buying books. If that event did not involve few critics, then it is not an event of buying few good books.

Returning to the narrower context where just local clubs are talked about, suppose that few good books have been bought, adding up all the outings. In this context, the events of buying few good books are still just the outings. As in sec. 3.5, this domain of events does not include further combinations of the outings. Although few good books have ever been bought, what happens across several outings is not another event in this domain. In particular, this domain does not include an event of buying few books that combines all the outings and involves perhaps all the critics. The implication about all the critics buying many good books can be drawn only if there really is something else that they were all in, like one of the national outings of the preceding paragraph.

We have already seen what the set-denotative interpretations imply in this context or any other. The objects of predication and quantification are sets of individuals unrestricted by any relationship to events. Although none of the individual local outings involve all the critics, the set-denotative interpretations of (154a) are true in this context only if all the critics,

if they are not few, are involved in buying many good books.

4.5

Later sections consider in more detail how quantifying over sets of individuals, if allowed, must depend on quantifying over individual events. That discussion makes use of a logic in which one can freely talk about both sets and events. As in the set-denotative logic of sec. 2, it assumes a domain of sets of individual objects; but it also distinguishes a domain of individual events. It is at first assumed that sets of individuals, like individual objects themselves, can be involved in diverse events. We then have an $n+1$ -ary predicate wherever we had an n -ary predicate in the set-denotative logic, adding a place for individual events: in the extended logic " $\Phi(v_1, \dots, v_n, e)$ " will be true of n sets and an event e just in case " $\Phi(v_1, \dots, v_n)$ " in the set-denotative logic would be true at e .

In all other respects, the extended logic follows the set-denotative logic. Thus, polyadic predicates are atomic relations (0.1), and plurality is treated by quantifying over sets of individuals according to clauses (15) and (16) in sec. 2.0. The later sections will then attack those differences that remain separating the set-denotative and related logics from event logic.

The argument of sec. 4.2. can be summarized conveniently in terms of the extended logic. Recall that it was shown that every set-denotative interpretation conforming to (153) results in unacceptable entailments for

the sentences so interpreted:

(153) $NP_1^{\text{non-increasing}} \langle NP^{\text{increasing}} \rangle^* NP_2^{\text{decreasing}} \phi(v_1, v^*, v_2)$

In terms of the extended logic, the argument shows that no sentence should be assigned an interpretation equivalent to either (186) or (187):

(186) $NP_1^{\text{non-increasing}} \langle NP^{\text{increasing}} \rangle^* NP_2^{\text{decreasing}} Ee \phi(v_1, v^*, v_2, e)$

(187) $Ee NP_1^{\text{non-increasing}} \langle NP^{\text{increasing}} \rangle^* NP_2^{\text{decreasing}} \phi(v_1, v^*, v_2, e)$

Consider once again (154a), which contains none of the increasing NP^* :

(154) a. Few critics bought few good books

An interpretation in the extended logic according to (186) would imply that, if all critics are more than few, there are many good books that they were all involved in buying in the course of one or more events. The occurrence of an existential quantifier over events with the narrowest scope does nothing to thwart the unacceptable implication. An interpretation conforming to (187) where the event quantifier has widest scope would likewise fail to avoid the unacceptable implication. It merely requires it to be true of some particular event.

The argument of sec. 4.2 shows that an existential quantifier over events with the restriction in (188) must come between the non-increasing NP_1 and the decreasing NP_2 , if one insists as does the extended logic on quantifying over sets at all:

(188) $NP_1(v_1)^{\text{non-increasing}} \dots [Ee: v_1 \text{ is in } e] \dots NP_2^{\text{decreasing}} \phi(v_1, v^*, v_2, e)^{51}$

51. The position of the event quantifier with respect to the increasing quantifiers NP^* is irrelevant.

An interpretation of (154a) according to (188) implies only that, if all the critics are not few, there is no event of buying few good books which they were all involved in. This is correct, and it is what the event-logical interpretations imply. The restriction on the event quantifier is necessary: an interpretation of (154a) parallel to (188) but omitting the restriction would imply that any set of not few critics has in any event bought not few good books. This interpretation, assuming there exists some event, would then also have the unacceptable implication that the set of all critics, if not few, has bought many good books.

The set-denotative logic without events cannot of course put the necessary event quantifier between NP_1 and NP_2 . It must assign interpretations to the sentences of (154)-(157) with unacceptable results. The event logic assigns only interpretations which have an effect equivalent to the interposed event quantifier in (188). We leave open for the moment how a set-denotative logic could assign interpretations like (188) while avoiding those like (186) and (187). We return to this question in sec. 5.3.

4.6

We turn now to the second peril in quantifying over sets unrestricted by a relationship to events. Here it is shown that no formula in set-denotative logic should be able to express an increasing relation, defined below. For if a formula Φ expresses an increasing relation, then all interpretations in set-denotative logic that conform to (189) will have implications that are unacceptable for the sentences they interpret.

(189) $NP_1^{\text{non-increasing}} (NP^{\text{non-decreasing}})^* NP_2^{\text{non-decreasing}} \phi$,
 where an $NP^{\text{non-decreasing}}$ that is non-increasing is interpreted
 only by (16b), as non-event-dependent.⁵²

An interpretation conforms to (189) in the familiar way. The first quantifier interpreted, the one assigned the widest scope, is non-increasing, and it may be interpreted either by (16a) as event-dependent or by (16b) as non-event-dependent. This quantifier, NP_1 , is followed by at least one non-decreasing quantifier, NP_2 . Any number of other non-decreasing quantifiers may also appear, NP^* . The non-decreasing quantifiers of NP^* and NP_2 may be either increasing ("(at least) three good books") or non-increasing ("exactly three good books"). Any of the increasing quantifiers may be interpreted by either clause of (15). If a non-decreasing quantifier in NP^* or NP_2 is non-increasing, it must be interpreted by (16b) to be non-event-dependent. As long as the scope assignment of (189) and the condition on non-increasing NP^* and NP_2 are respected, we are interested in interpreting the quantifiers by all combinations obtainable from (15) and (16).

The set-denotative interpretations conforming to (189) are unacceptable if " ϕ " expresses an increasing relation. We first define increasing relations and discuss their expression in set-denotative logic before showing the unacceptable implications of (189). In the definition, the values of the variables are sets, as expected in set-denotative logic, and $n \geq 2$:

(190) " ϕ " expresses an increasing relation if:

$$(x_1) \dots (x_n)(y_1) \dots (y_n) \quad \phi(x_1, \dots, x_n) \ \& \ \phi(y_1, \dots, y_n) \rightarrow \phi(x_1 U y_1, \dots, x_n U y_n)$$

52. See n. 38.

The expressed relation is increasing if it is closed under the union operation shown in (190). If an increasing, n -ary relation is true of any two n -tuples, $\langle x_1, \dots, x_n \rangle$ and $\langle y_1, \dots, y_n \rangle$, it is also true of the union n -tuple $\langle x_1 \cup y_1, \dots, x_n \cup y_n \rangle$.

Unfortunately, the expression of increasing relations is difficult to avoid in a set-denotative logic without events. There are two cases. In the first case, " Φ " is an atomic predicate expressing an increasing relation, and in the second, an increasing relation is expressed by a complex formula " Φ " free in at least two variables.

Recall that set-denotation is an account of all aspects of the problem that sentences with plural arguments have interpretations that are not reducible to predications about individuals (within the standard assumptions 0.1-0.3). The set-denotative treatment of the sum of plurals, that aspect of the problem discussed in sec. 1.1, 2.1 and 2.4.1., provides instances of the first case, atomic predicates that express increasing relations.

- (3) a. Ten boys ate ten pies
 b. The boys ate the pies
 c. They ate them
- (4) a. Ten boys carried fifty cartons home
 b. The boys carried the cartons home
 c. They carried them home

Recall that nonreducibility for the examples in (3) came from the truth of the sum of plurals interpretation in situations where the boys shared the pies. Some of these situations may in fact contain no boy and no pie of whom it is true that he ate it. He may at best have tasted it if he ate of that one at all. Hence, the sum of plurals interpretation of (3) is not equivalent to any number of sentences about individual boys and pies.

Similarly, the sum of plurals interpretations of (4) can be true even if the cartons were passed from one boy to another on their way home, although in such situations a box was not in general carried home by a boy. Faced with the non-reducibility of the sum of plurals to predication about individuals, the set-denotative logic assumes that atomic predicates, such as carry home(x,y) and eat(x,y), express relations between sets of individuals⁵³. The predicates involved are not exceptional. The non-reducibility of the sum of plurals seems to be a general feature of sentences with plurals.

Atomic predicates such as carry home(x,y) and eat(x,y) express increasing relations. To see this, it will be simpler to suppose first that, contrary to what has been observed in the preceding paragraph, that the relations between sets can be reduced to relations between their members:

- (191) "eat(c,d)" is true iff every individual in c eats some individual in d and every individual in d is eaten by some individual in c
- (192) "carry home(c,d)" is true iff every individual in c carries home some individual in d and every individual in d is carried home by some individual in c

With truth conditions such as those in (191) and (192), the relations expressed are surely increasing. Suppose that "carry home(c_1, d_1)" and "carry home(c_2, d_2)" are true. It follows from (192) that every individual in $c_1 \cup c_2$ carries home some individual in $d_1 \cup d_2$ and every individual in $d_1 \cup d_2$ is carried home by some individual in $c_1 \cup c_2$, which are the truth conditions for "carry home($c_1 \cup c_2, d_1 \cup d_2$)".

53. See sec. 2.4.2. We again let the verbs stand in for the atomic predicates which could just as well be boys(x) carry home cartons(y) and boys(x) eat pies(y). For our purposes, " Φ " in a simple sentence is atomic if it includes no quantifiers. See sec. 2.4.2.

The nonreducibility of the actual relations expressed derives from a weakening in the above truth conditions, but the relations remain increasing. The actual relations are true of any sets c and d that meet (191) and (192), but they are also true of sets that fail these conditions as in the above situations, where pies are shared and cartons passed around. Despite possible counterexamples to (190) among the new sets, the weaker truth conditions in (193) and (194) still describe increasing relations:

(193) "eat(c, d)" is true iff every individual in c participates in eating some individuals in d and every individual in d is eaten by some individuals in c .

(194) "carry home(c, d)" is true iff every individual in c participates in carrying home some individuals in d and every individual in d is carried home by some individuals in c .

Suppose that "carry home(c_1, d_1)" and "carry home(c_2, d_2)" are now true according to the conditions in (194). Since, every individual in c_1 participates in carrying home some individuals in d_1 , every individual in c_1 participates in carrying home some individuals in the union of d_1 and d_2 . Similarly, every individual in c_2 participates in carrying home some individuals in the union of d_1 and d_2 , since he participates in carrying home some individuals in d_2 . It then follows that every individual in the union of c_1 and c_2 participates in carrying home some individuals in the union of d_1 and d_2 . Similar remarks show that every individual in the union of d_1 and d_2 is carried home by some individuals in the union of c_1 and c_2 , and thus "carry home($c_1 \cup c_2, d_1 \cup d_2$)" is true. The nonreducible relation expressed by the atomic predicate is increasing.

Note that the increasing-ness of the relations expressed by the atomic predicates accounts for the deductions in (195) and (196), which are valid

when the premises and conclusions are interpreted as sums of plurals.

- (195) These ten boys₁ ate these ten pies₁
 Those ten boys₂ ate those ten pies₁

 The twenty boys_{1U2} ate the twenty pies_{1U2}
- (196) These ten boys₁ carried these ten cartons₁ home
 Those ten boys₂ carried those ten cartons₁ home

 The twenty boys_{1U2} carried the twenty cartons_{1U2} home

In set-denotative logic, when the quantifiers in (195) and (196) are interpreted by clause (15a) to make undivided reference to a denotatum, the sum of plurals interpretations are equivalent to (197) and (198).

(15) Increasing quantifiers.

- a. (undivided reference to a denotatum) "[Q N'] $\Phi(x)$ " is true iff for some (set) c, c is [Q N']-many, and " $\Phi(c)$ " is true.
- b. (divided reference to denotata) "[Q N'] $\Phi(x)$ " is true iff for some (sets) c_1, \dots, c_k, \dots , the union of c_1, \dots, c_k, \dots is [Q N']-many, and " $\Phi(c_1)$ " is true...and " $\Phi(c_k)$ " is true....

- (197) [Ex: these ten boys₁(x)][Ey: these ten pies₁(y)] ate(x,y)
 [Ex: those ten boys₂(x)][Ey: those ten pies₂(y)] ate(x,y)

 [Ex: the twenty boys_{1U2}(x)][Ey: the twenty pies_{1U2}(y)] ate(x,y)
- (198) [Ex: these ten boys₁(x)][Ey: these ten cartons₁(y)] carried home(x,y)
 [Ex: those ten boys₂(x)][Ey: those ten cartons₂(y)] carried home(x,y)

 [Ex: the twenty boys_{1U2}(x)][Ey: the twenty cartons_{1U2}(y)] carried home(x,y)

(197) and (198) can be valid only if the atomic predicates express increasing relations.⁵⁴

54. In light of sec. 2.4.1, the significance of these deductions for set-denotative logic should not be overstated. The method of n-ary quantification discussed there would allow us to obtain the deductions from

 non-increasing atomic predicates. Recall the discussion of "collaborate on(x,y)", a non-increasing relation according to the conditions in (22):

(22) "collaborate on(c_1, c_2)" is true iff everyone of c_1 collaborated with everyone of c_2 on every one of c_2 .

These conditions impose an intimate collaboration on any sets denoted by the predicate. The sentence in (23) can however be true even if the composers and the operas are divided among separate collaborations.

(23) These composers collaborated on these operas.

The weaker truth conditions of the sentence are obtained through the quantification. these composers and these operas are interpreted as a single binary quantifier over ordered pairs of sets, and it allows for divided reference to denotata (cf. (15b)). The resulting truth conditions for the sentences are in (24):

(24) "[these composers] X [these operas]($\langle x, y \rangle$) collaborate on(x,y)" is true iff for sets c_1, \dots, c_k the union of which is these composers and for sets o_1, \dots, o_k the union of which is these operas, "collaborate on(c_1, o_1)" is true, ... and "collaborate on(c_k, o_k)" is true.

Despite the non-increasing atomic relation, the sentences in (199) can be interpreted as in (200) to obtain a valid deduction.

(199) These ten composers₁ collaborated on these ten operas₁.

Those ten composers₂ collaborated on those ten operas₂.

 The twenty composers_{1U2} collaborated on the twenty operas_{1U2}.

(200) [these ten composers₁] X [these ten operas₁]($\langle x, y \rangle$) collaborated on(x,y)

[those ten composers₂] X [those ten operas₂]($\langle x, y \rangle$) collaborated on(x,y)

 [the twenty composers_{1U2}] X [the twenty operas_{1U2}]($\langle x, y \rangle$) collaborated on(x,y)

Returning to the examples in the text, the method of n-ary quantification shows that the valid deductions in (195) and (196) do not in themselves compel set-denotative logic to make the atomic predicates "carry home(x,y)" and "eat(x,y)" express increasing relations. But, if the set-denotative logic permits a derivation of the sum of plurals interpretations, equivalent to what is shown in (197), then the validity of the deduction does require the atomic relations to be increasing. This conclusion can be avoided just in case the n-ary quantification is the only way to obtain the sum of plurals, eliminating (15a) (undivided reference to a denotatum).

The desirability of such a step may depend in part on observations like the following. Although the deductions in (195) and (196) are unequivocally

In the second case where set-denotative logic expresses an increasing relation, " Φ " is a complex formula free in at least two variables. The examples we construct start with an atomic predicate in three variables that does not express an increasing relation. When one of the variables is bound by a decreasing quantifier, the resulting formulas with two free variables express increasing relations. Consider the atomic predicates in (202), where again the values of the variables sets:

- (202) x are in agreement (to a man) about z with y
 x consult as much as possible on z with y
 x collaborated completely on z with y
 x form a Cartesian product with y in extensions of z 55

These are not increasing. Suppose $\langle a_1, b_1, c_1 \rangle$ and $\langle a_2, b_2, c_2 \rangle$ satisfy the first predicate. It does not follow that $\langle a_1 U a_2, b_1 U b_2, c_1 U c_2 \rangle$ also satisfies the predicate. What is required is that everyone in $\underline{a_1 U a_2}$ is in agreement with everyone in $\underline{b_1 U b_2}$ (about $\underline{c_1 U c_2}$), but the agreements that hold of the separate groups do not entail the larger, complete agreement that is required when the groups are considered together. In fact, $\underline{a_1}$ may completely disagree with $\underline{b_2}$, and $\underline{a_2}$ with $\underline{b_1}$. Furthermore, whatever accord exists originally

 valid, the validity of (199) does seem to hinge on an ambiguity in the premises and conclusion. Note that the deduction is not valid, given that the atomic relation is not increasing ((22)), if the quantifiers are interpreted by (15a):

- (201) $[Ex: \text{these ten composers}_1(x)][Ey: \text{these ten operas}_1(y)]$ collaborated on $\langle x, y \rangle$
 $[Ex: \text{those ten composers}_2(x)][Ey: \text{those ten operas}_2(y)]$ collaborated on $\langle x, y \rangle$

 $[Ex: \text{the twenty composers}_{1U2}(x)][Ey: \text{the twenty operas}_{1U2}(y)]$ collaborated on $\langle x, y \rangle$

The fact that the premises and conclusion can be construed to invalidate the deduction is a reason to keep (15a), since this result could not be obtained with n -ary quantification.

55. See n.53.

between \underline{a}_1 and \underline{b}_1 may be shattered when \underline{c}_2 is added to the equation. Similar considerations show that the other predicates are also not increasing.

When \underline{z} in (202) is bound by a decreasing quantifier, the resulting formula free in \underline{x} and \underline{y} expresses an increasing relation:

- (203) x are in agreement (to a man) about few world problems with y
 x consult as much as possible on none of the projects with y
 x collaborated completely on hardly any operas with y
 x form a Cartesian product with y in extensions of few relations

Suppose there are few world problems that \underline{a}_1 are in agreement with \underline{b}_1 about, and there are few world problems that \underline{a}_2 are in agreement with \underline{b}_2 about. For any world problems, whichever individuals are exceptions to complete agreement between the members of \underline{a}_1 and the members of \underline{b}_1 or between the members of \underline{a}_1 and the members of \underline{b}_1 are also exceptions to complete agreement between the members of \underline{a}_{1U2} and the members of \underline{b}_{1U2} . Any world problems about which there is a larger agreement must be among those that belong both to the few problems about which \underline{a}_1 and \underline{b}_1 are in agreement and to the few problems about which \underline{a}_2 and \underline{b}_2 are in agreement. There are therefore few world problems which \underline{a}_{1U2} is in agreement with \underline{b}_{1U2} about, and so the formula expresses an increasing relation. The other formulas in (203) can be similarly shown to express increasing relations.

We return now to (189) to show that all conforming interpretations in set-denotative logic have unacceptable implications when " Φ " expresses an increasing relation.

- (189) $NP_1^{\text{non-increasing}} (NP^{\text{non-decreasing}})^* NP_2^{\text{non-decreasing}} \Phi,$

where an $NP^{\text{non-decreasing}}$ that is non-increasing is interpreted only by (16b), as non-event-dependent.

The sentences in (204)-(206) are simple examples where the number of intervening non-decreasing quantifiers (NP^*) in the relevant interpretations is zero, and the increasing relation is expressed by an atomic predicate:

- (204)a. Few critics bought (at least) three good books
- b. Only a few critics bought exactly three good books
- c. Not more than ten critics bought some of the books
- d. Exactly ten critics bought (at least) three good books
- e. Exactly ten critics bought exactly three good books

- (205)a. Few boys ate (at least) three pies
- b. Only a few boys ate exactly three pies
- c. Not more than ten boys ate some of the pies
- d. Exactly ten boys ate (at least) three pies
- e. Exactly ten boys ate exactly three pies

- (206)a. Few boys carried (at least) three cartons home
- b. Only a few boys carried exactly three cartons home
- c. Not more than ten boys carried some of the cartons home
- d. Exactly ten boys carried (at least) three cartons home
- e. Exactly ten boys carried exactly three cartons home

The interpretations conforming to (189) attribute to these sentences truth conditions they in fact do not have. This outcome is a consequence of quantifying over a domain that includes all sets of individuals unrestricted by a relationship to events.

We demonstrate the unacceptability of these interpretations for the examples (204a) and (204e), which illustrate the two cases of non-increasing NP_1 , decreasing "few critics" and non-decreasing "exactly ten critics", and the two cases of non-decreasing NP_2 , increasing "(at least) three good books" and non-increasing "exactly three good books". The unacceptability of these interpretations can be demonstrated for other examples in the same way.

In set-denotative logic, the domain of quantification includes any set of individual objects there are (except the empty set). As in sec. 4.2, we allow that the existing or relevant individual objects may depend on the

context for the sentence. Thus, "few critics" in (204a) may be intended to mean few of the critics at hand. Now relative to any context, the domain of quantification in set-denotative logic includes every subset, except the empty set, of relevant individual objects (see n. 41). As in sec. 4.2., to reveal unacceptable implications of the interpretations that conform to (189), we use particular instances of the sets quantified over. Membership in the sets specified by the following definitions again depends on the given context. Let B^*C be the set of critics who bought good books, and let B^*B be the set of good books bought by critics:

- (207) $B^*C = \{x: \text{critic}(x) \ \& \ \text{Er}(x \in r) \ \& \ \text{Es}(\text{good books}(s) \ \& \ r \text{ bought } s)\}$
 $B^*B = \{y: \text{good book}(y) \ \& \ \text{Es}(y \in s) \ \& \ \text{Er}(\text{critics}(r) \ \& \ r \text{ bought } s)\},$
 x and y are individual-variables, and r and s are set-variables.

The significance of the sets in (207) is apparent from their construction as follows. Let B be the extension of critics(r) buy good books(s) in a given context. It contains all and only pairs $\langle r, s \rangle$ such that r is a set of critics, s is a set of good books and r bought s . We derive the sets in (207) from the domain and range of B . B^*C is $U\{r: \text{Es } \langle r, s \rangle \in B\}$, and B^*B is $U\{s: \text{Er } \langle r, s \rangle \in B\}$. The domain and range are each a set of sets of individuals. The union of each obtains one of the sets of individuals in (207). Thus, B^*C is the union of the domain of the extension of critics(r) buy good books(s), and B^*B is the union of the range of the extension of critics(r) buy good books(s).

Recall that buy(r, s) and now more specifically, critics(r) buy good books(x), express an increasing relation, as defined in (190). It follows from this property of the predicates and the definitions of B^*C and B^*B that:

(208) "critics(B"C) bought good books(B"B)" is true.

The pair $\langle B"C, B"B \rangle$ is itself in the extension of the increasing relation.

The argument below relies on (208). For the general case represented by

(189), we construct sets in the same way to obtain analogues of (208). " Φ "

is a formula that expresses an increasing relation in $n \geq 2$ places. Let

N'_1, \dots, N'_n stand for the restrictions on the quantifiers that bind places in

" Φ " (cf. "critics" in "few critics" and "good books" in "three good

books"). We define $\Phi"N'_i, 1 \leq i \leq n$, as follows:

(209) $\Phi"N'_i = \{x: N'_i(x) \ \&, \text{ for } 1 \leq j < i \leq n,$

$\text{Er}(x \text{Er} \ \& \ \text{Es}_j \dots \text{Es}_k(N'_j(s_j) \ \& \dots \& \ N'_k(s_k) \ \& \ \Phi(s_j, \dots, r, \dots, s_k))\}$

The analogue to (208), which holds because " Φ " expresses an increasing relation is (210):

(210) " $\Phi(\Phi"N'_1, \dots, \Phi"N'_n)$ " is true.

The argument below relies on (208) and in the general case on (210). " Φ " is

required to express an increasing relation solely to obtain these

statements. The argument follows closely the one in sec. 4.2., nearly word

for word. ⁵⁶

In the first example in (204a), NP_1 in (189) is a decreasing quantifier "few critics". We must consider both of its interpretations in set-denotative logic, as an event-dependent quantifier according to (16a) and as a non-event-dependent quantifier according to (16b). These

56. The following argument is again unchanged if the atomic predicate does not incorporate the nominals, buy(r,s). But, substitute for all occurrences of B"C, B"X the set of all buyers, and for all occurrences of B"B, B"Y the set of all things bought. The yet stranger implications will be stated in a later footnote.

interpretations are equivalent respectively to (211) and (212), which are instances of (152a) and (152b). The values of r, s and t are sets:

(211) $\text{Ar}(\text{critics}(\text{r}) \text{ bought (at least) three good books} \rightarrow \text{few critics}(\text{r}))$

(212) $\text{Es}((\text{few critics}(\text{s}) \& \text{Ar}(\text{critics}(\text{r}) \text{ bought (at least) three good books} \rightarrow \text{rCs})) \& \text{At}((\text{Ar}(\text{critics}(\text{r}) \text{ bought few good books} \rightarrow \text{rCt}) \rightarrow \text{sCt}))$

The event-dependent interpretation of (204a) is true according to set-denotative logic if and only if ((211)) every set (of critics) that bought (at least) three good books is few critics. Thus, any set (of critics) is either few critics or did not buy (at least) three good books:

(213) $\text{Ar}(\text{few critics}(\text{r}) \text{ or not}(\text{critics}(\text{r}) \text{ bought (at least) three good books}))$

The non-event-dependent interpretation imposes stronger conditions, which in fact entail the event-dependent interpretation. It is true according to set-denotative logic if and only if (212) the union of every set (of critics) that bought (at least) three good books is few books. Any one set (of critics) in the domain is either a subset of a particular set of few critics and is a fortiori itself few critics or did not buy (at least) three good books:

(214) $\text{Es}((\text{few critics}(\text{s}) \& \text{Ar}(\text{rCs or not}(\text{critics}(\text{r}) \text{ bought (}) \text{three good books})) \& \text{At}((\text{Ar}(\text{critics}(\text{r}) \text{ bought (}) \text{three good books} \rightarrow \text{rCt}) \rightarrow \text{sCt}))$

Similar remarks pertain to the second case where NP_1 is "exactly ten critics" in (204e). We must consider both of its interpretations in set-denotative logic, as an event-dependent quantifier according to (16a) and as a non-event-dependent quantifier according to (16b). These interpretations are equivalent respectively to (215) and (216), which are instances of (152a) and (152b). The values of r, s and t are sets:

(215) $\text{Ar}(\text{critics}(r) \text{ bought exactly three good books} \rightarrow \text{exactly ten critics}(r))$

(216) $\text{Es}((10! \text{ critics}(s) \ \& \ \text{Ar}(\text{critics}(r) \text{ bought } 3! \text{ good books} \rightarrow rCs))$
 $\ \& \ \text{At}((\text{Ar}(\text{critics}(r) \text{ bought } 3! \text{ good books} \rightarrow rCt) \rightarrow sCt))$

The event-dependent interpretation of (204e) is true according to set-denotative logic if and only if ((215)) every set (of critics) that bought exactly three good books is exactly ten critics. Thus, any set (of critics) is either ten critics or did not buy exactly three good books:

(217) $\text{Ar}(\text{exactly ten critics}(r) \text{ or } \text{not}(\text{critics}(r) \text{ bought exactly three good book$

The non-event-dependent interpretation is true according to set-denotative logic if and only if (216) the union of every set (of critics) that bought exactly three good books is exactly ten books. Any one set (of critics) in the domain is either a subset of a particular set of ten critics or did not buy exactly three good books:

(218) $\text{Es}((10! \text{ critics}(s) \ \& \ \text{Ar}(rCs \text{ or } \text{not}(\text{critics}(r) \text{ bought } 3! \text{ good books}))$
 $\ \& \ \text{At}((\text{Ar}(\text{critics}(r) \text{ bought } 3! \text{ good books} \rightarrow rCt) \rightarrow sCt))$

The expressions last seen representing the truth conditions of event-dependent and non-event-dependent NP_1 contain in a disjunct the non-decreasing quantifiers corresponding to NP_2 in (189), either the non-decreasing, increasing "(at least) three good books" or the non-decreasing, non-increasing "exactly three good books":

(213), (214) ...or not(critics(r) bought (at least) three good books)...

(217), (218) ...or not(critics(r) bought exactly three good books)...

We must consider the interpretations of the increasing NP_2 under both clauses of (15), as making undivided reference to a denotatum and as divided among denotata. Observing the condition on non-increasing NP_2 , we consider only its interpretation by clause (16b), as non-event-dependent. The values of u ,

v and w are also sets, and the values of x are individual objects:

(219) from (213) and (214) a. (undivided ref.):

...or not[Eu((?)3 good books(u) & critics(r) bought good books(u))]....

b. (divided ref.):...or not[Ev((?)3 good books(v) &

Ax(xεv → Eu(xεu & u⊆v & critics(r) bought good books(u)))]....

(220) from (217) and (218) (non-ev. dep.):

...or not[Eu ((3! good books(u) & Av(critics(r) bought good books(v) → v⊆u))
& Aw((Av(critics(r) bought good books(v) → v⊆w) → u⊆w))]....

Pushing through the negation these are equivalent to:

(221) from (213) and (214) a. (undivided ref.):

...or Au(not((?)3 good books(u) or not(critics(r) bought good books(u)))...

b. (divided ref.):...or Av (not((?)3 good books(v)) or

Ex(xεv & Au(not(xεu) or not(u⊆v) or not(critics(r) bought good books(u))))).

(222) from (217) and (218) (non-ev. dep.):

...or Au ((not(3! good books(u)) or Ev(critics(r) bought good books(v) & not(v⊆u))
or Ew((Av(critics(r) bought good books(v) → v⊆w) & not(u⊆w))))...

Recall that we are to use B"C and B"B, the set of all critics who bought good books and the set of all good books bought by critics (in whatever context) as a particular instance of the sets quantified over to reveal unacceptable implications of the set-denotative interpretations of (204a) and (204e) which conform to (189). (204a) under any combination of (213) or (214) with (221a) or (221b) will require B"C to meet at least the condition in (223), where x is a variable over individual objects:

(223) few critics(B"C) or Au(not((at least) three good books(u) or
not(critics(B"C) bought good books(u)))

For if B"C is not few critics it is also not a subset of few critics. The event-dependent interpretation and the non-event dependent interpretation of (204a) then require that B"C not have bought (at least) three books. That is, B"C bought fewer than three good books, whether "(at least) three books" is interpreted as having divided or undivided reference. If "(at least)

three books" is interpreted as having undivided reference ((221a)), there is no set of (at least) three books that BⁿC bought. If the quantifier is interpreted as divided among denotata ((221b)), then there is no set of (at least) three good books whose members can be divided up among sets each of which BⁿC bought. Of course any set proscribed by the first interpretation is also proscribed by the second. Such a set, a set of (at least) three good books that BⁿC bought, is just the special case where the members of a set of (at least) three good books are divided up among only one set that BⁿC bought. Thus, (223) represents the weakest condition on BⁿC required by all the set-denotative interpretations.

Similar remarks show that (204e) under any combination of (217) or (218) with (222) requires BⁿC to meet at least the condition in (224):

(224) exactly ten critics(BⁿC) or $\text{Au} \langle \langle \text{not}(\text{exactly three good books}(\text{u})) \text{ or } \text{Ev}(\text{critics}(\text{B}^n\text{C}) \text{ bought good books}(\text{v}) \ \& \ \text{not}(\text{vCu})) \rangle \rangle \text{ or } \text{Ew}(\langle \text{Av}(\text{critics}(\text{B}^n\text{C}) \text{ bought good books}(\text{v}) \rightarrow \text{vCw}) \ \& \ \text{not}(\text{uCw})) \rangle \rangle$

The second disjunct comes directly from (222) by substituting BⁿC for n. Concerning the first disjunct, it should be pointed out that the non-event-dependent interpretation of "exactly ten critics" would not imply (224) if BⁿC were any arbitrary set⁵⁷; but, as the set of all critics that bought good books, BⁿC cannot be less than ten critics if the

57. For an arbitrary set S, the non-event dependent interpretation implies (i):

(i) ten critics(S) or $\text{Au} \langle \langle \text{not}(\text{exactly three good books}(\text{u})) \text{ or } \text{Ev}(\text{critics}(\text{S}) \text{ bought good books}(\text{v}) \ \& \ \text{not}(\text{vCu})) \rangle \rangle \text{ or } \text{Ew}(\langle \text{Av}(\text{critics}(\text{S}) \text{ bought good books}(\text{v}) \rightarrow \text{vCw}) \ \& \ \text{not}(\text{uCw})) \rangle \rangle$

(223) would still be implied by all of (204a)'s interpretations if BⁿC were an arbitrary set.

non-event-dependent interpretation is true, since there must be exactly ten critics buying exactly three good books. If B^*C is more than ten critics, then this interpretation requires that B^*C not buy exactly three good books, as in (224).

Instantiating the universal quantifier " Au " in (223) and (224) with B^*B , we have (225) implied by (204a) and (226) implied by (204e):

(225) few critics(B^*C) or not((at least) three good books(B^*B) or not(critics(B^*C) bought good books(B^*B)))

(226) exactly ten critics(B^*C) or (not(exactly three good books(B^*B)) or Ev (critics(B^*C) bought good books(v) & not(vCB^*B))) or Ew ((Av (critics(B^*C) bought good books(v) $\rightarrow vCw$) & not(B^*BCw)))

Now, since "critics(B^*C) bought good books(B^*B)" is true by (208), the last disjunct of (225) cannot obtain. (204a) therefore implies (227):

(227) few critics(B^*C) or not((at least) three good books(B^*B))

Also (204e) implies (228), since B^*B cannot satisfy the other disjuncts of (226):

(228) exactly ten critics(B^*C) or (not(exactly three good books(B^*B)))

As B^*B is defined, any set of good books that B^*C bought is a subset of B^*B . Thus B^*B does not satisfy the second disjunct. B^*B is also the least set that any set of good books that B^*C bought is a subset of, which excludes the third disjunct.

Recalling their definition in (207), what is implied about B^*C and B^*B by the various set-denotative interpretations of (204a) and (204e) can be paraphrased as follows:

(229) [(204a) implies that in the given context] few critics bought good books, there are not (at least) three good books bought by critics.

(230) [(204e) implies that in the given context] exactly ten critics⁵⁸ bought good books, or not exactly three good books were bought by critics.

Recall that the claim was that all interpretations in set-denotative logic that conform to (189) have unacceptable truth conditions.

(189) $NP_1^{\text{non-increasing}} (NP^{\text{non-decreasing}})^* NP_2^{\text{non-decreasing}} \diamond$,
 where an $NP^{\text{non-decreasing}}$ that is non-increasing is interpreted only by (16b), as non-event-dependent.

We provide now a schema that shows an unacceptable implication in the general case when there are one or more non-decreasing quantifiers:

(231) $NP_1^{\text{non-increasing}} NP_2^{\text{non-decreasing}} \dots NP_n^{\text{non-decreasing}} \diamond$,
 where an $NP^{\text{non-decreasing}}$ that is non-increasing is interpreted only by (16b), as non-event-dependent.

These conditions are obtained by reasoning as above. It is left to the reader to verify that for the sets defined in (209) all set-denotative interpretations conforming to (231) in which " \diamond " expresses an increasing relation imply (232):

(232) $NP_1^{\text{non-increasing}} (\diamond "N'_1)$ or
 $\text{not}(NP_2^{\text{non-decreasing}} (\diamond "N'_2))$ or ... or $\text{not}(NP_n^{\text{non-decreasing}} (\diamond "N'_n))$

A schematic paraphrase of (232) is:

(233) $NP_1 \diamond\text{-ed } N'_2\text{'s} \dots P N'_n\text{'s}$, or
 there were not NP_2 that were $\diamond\text{'ed}$ by $N'_1\text{'s} \dots P N'_n\text{'s}$, or...

58. If the argument is modified according to n. 56, we obtain instead:

(229') [(204a) implies that in the given context] few critics bought things,
 or there are not (at least) three good books bought by anyone.

(230') [(204e) implies that in the given context] exactly ten critics bought things
 or not exactly three good books were bought by anyone.

there were not NP_n that N'_1 s Φ 'ed N'_2 s P .

The argument as presented used examples (204a) and (204e), where " Φ " is an atomic predicate. As seen in (203), " Φ " can be a complex formula that expresses an increasing relation, such as "x are in agreement about few world problems with y". The same argument except for obvious substitutions will show that set-denotative interpretations of (234) will have the unacceptable implications in (235):

- (234)a. Few of the Democrats are in agreement about few world problems with exactly three Republicans.
- b. Exactly ten Democrats are in agreement about few world problems with (at least) three Republicans.
- (235)a. There are few Democrats in agreement about few world problems with Republicans, or there are not exactly three Republicans who any Democrats are in agreement about few world problems with.
- b. There are exactly ten Democrats in agreement about few world problems with Republicans, or there are not (at least) three Republicans who any Democrats are in agreement about few world problems with.

Because " Φ " can be a complex formula, a given sentence may have a variety of unacceptable interpretations:

(236) $NP_1^{\text{non-incr}} NP_2^{\text{non-decr}} \Phi_2^{\text{non-decr}} NP_3^{\text{non-decr}} \Phi_3^{\text{non-decr}} \dots NP_k^{\text{non-decr}} \Phi_k^{\text{non-decr}} (R))$

The above argument show how to be construct one for each " Φ_i " in (236) if it expresses an increasing relation for the variables free in " Φ_i ". Thus, the set-denotative interpretations of the sentence in (237) can be shown to imply (238) if " Φ " is taken to be "critics(r) bought good books(s) at at least three used book stores" and to imply (239) if " Φ " is taken to be "critics(r) bought good books(s) at used book stores(t)".

(237) Few critics bought at least ten good books at at least three used book stor

(238) Few critics bought good books at at least three used book stores, or there were not at least ten good books bought by critics at

at least three used book stores.

(239) Few critics bought good books at used book stores, or there were not at least ten good books bought by critics at used book stores, or there were not at least three used book stores that any critics bought good books at.

4.7

It may be helpful to compare the unacceptable interpretations assigned by set-denotative logic with acceptable interpretations.

4.7.1

Consider first those interpretations in which the scope indicated in (189) is assigned to standard quantifiers, which bind variables whose values are individual objects:

(240) [Few x : critic(x)] [(≥ 3) y : good book(y)] critic(x) bought good book(y)

(241) [10! x : critic(x)] [3! y : good book(y)] critic(x) bought good book(y)

When an arbitrary set is more than few critics, (240) requires that at least one individual critic does not satisfy the formula within the scope of NP_1 , viz., "[Few x : critic(x)] [(at least) three y : good book(y)] critic(x) bought good book(y)". That is at least one of them did not buy (at least) three good books; he bought one or two or none. This is a possible interpretation of (204a). Note that the conditions imposed by this interpretation are met by a set of many critics, who are all buying good books, if for example each bought exactly one. But, the set-denotative interpretations conforming to (189) could be true of such a set only if there were not at least three good books bought by members of that set. There must be one or two good books

that every good book bought by a member is identical to one of.

Similarly, when an arbitrary set is more than ten critics, (241) requires that at least all but ten of the critics in that set each fails to satisfy "[exactly three y : good book(y)] critic(x) bought good book(y)". Each of all but ten bought some other number of good books. They could have all bought some good books. But, in this case, the set-denotative interpretations of (204e) conforming to (189) could be true only if their collected purchases were exactly three good books.

As we have seen, the domain of set-denotative logic includes every set of relevant individuals. We were thus able to choose in particular B^*C and B^*B . Given their definition and the increasing property of "critics(r) bought good books(s)", B^*C bought B^*B . The conditions imposed on arbitrary sets of book-buying critics and good books bought by critics imply what we have seen in (227) and (228) for the particular sets B^*C and B^*B .

4.7.2

It should not be mistakenly concluded from the discussion of sec. 4.6. that no interpretation of examples in (204)–(206) will ever impose conditions on the entire domain and range of a relation's extension in a given context, analogous to B^*C and B^*B , which are all the critics buying good books and all the good books bought by critics in a given context.

To varying degrees of acceptability, these sentences admit a sum of plurals

interpretation⁵⁹. This is not one of the excluded interpretations conforming to (189), since, it should be recalled, none of the plurals is within the scope of another in a sum of plurals. This interpretation of (204a) means that few critics bought good books and (at least) three good books were bought by critics. Similarly, in the case of (204e), it means that exactly ten critics bought good books and exactly three good books were bought by critics.

In any context in which BⁿC bought BⁿB, the sum of plurals interpretations of (204a) and (204e) will require respectively the conditions in (242) and (243) to be met:

- (242) few critics(BⁿC) & (at least) three good books(BⁿB)
- (243) exactly ten critics(BⁿC) & exactly three good books(BⁿB)

Note that in any context in which (242) is true, (227) is also true, although it was judged that (227) is not a valid implication of either the event-dependent or non-event-dependent interpretation of (204a). Similarly, (228), an unacceptable implication of any set-denotative interpretation of (204e) that conforms to (189), is true in any context in which (243) obtains. Nevertheless, the sum of plurals interpretation cannot be confounded with these others.

First, in any context in which a sum of plurals interpretation imposes the conditions in (242) or (243), it does not impose such a condition on any other sets. As we have seen, the set-denotative interpretations conforming to

59. It is somewhat marginal if the subject, NP₁, is a decreasing quantifier, as in the much discussed nobody loves nobody with the meaning that nobody loves and nobody is loved. See May (1984).

(189) quantify over all the sets of individuals in a given context. Second, there are situations of which the set-denotative interpretations conforming to (189) are true but not the sum of plurals. Thus, these interpretations of (204a) are true, although the sum of plurals interpretation is false, if every critic bought exactly one and the same good book. Since, only one good book was bought by critics, the interpretations conforming to (189) are verified. The sum of plurals interpretation is false because fewer than three good books were bought by critics.

4.8 Comparison with event logic

(244)-(245) represent the event logic for event-dependent and non-event-dependent interpretations of (204a) and (204e). Recall that the values of e are events and the values of x are individual objects⁶⁰:

(244)a.(ev.-dep.) $[Ae: \text{buy (at least) 3 good books}(e)][\text{few critics}(x)] x \in e$

b.(non-ev.-dep.) $[\text{few critics}(x)][Ee: \text{buy (at least) 3 good books}(e)] x \in e$

(246)a.(ev.-dep.) $[Ae: \text{buy exactly 3 good books}(e)][\text{exactly 10 critics}(x)] x \in e$

b.(non-ev.-dep.) $[\text{exactly 10 critics}(x)][Ee: \text{buy exactly 3 good books}(e)] x \in e$

In event logic, conditions on arbitrary sets are entirely derived from quantifying over events in which their members participated. In an event-dependent interpretation such as (244a), NP_1 "few critics" is a condition on an arbitrary set just in case the members of that set are the

60. For explicitness, we retain the notation in which " \in " stands for "is involved in". See the discussion in sec. 3.3 in which logical forms without " \in " are adopted.

participants in an event of buying (at least) three good books. When an arbitrary set is more than few critics, (244a) requires only that there be in the given context no such event whose participants are the members of that set. In particular when B^*C is more than few critics, (244a) requires that there be no event of buying (at least) three good books by B^*C . B^*B will be required to be not (at least) three good books just in case the context contains an individual event of critics buying good books in which some critics who are not few bought B^*B . Thus, in contrast to the set-denotative conditions in (227), some contexts in which the event-logical interpretation (244a) is true meet only the third condition in (247):

(247) few critics(B^*C) or not((at least) three good books(B^*B))
 or there is no event of B^*C buying B^*B

Similar remarks apply to the event logic for non-event-dependent interpretations, as in (244b). When an arbitrary set is more than few critics, (244b) requires that not all of its members participated in events of buying (at least) three good books. In particular, there is no one such event in which all of its members are the participants. Thus, if B^*C is more than few critics, its members are not participants in events of buying (at least) three good books, and, in particular, there is no one event of buying (at least) three good books in which the members of B^*C are the participants. The quantity of B^*B is unaffected unless there is an individual event of critics buying B^*B . Thus, some contexts in which (244b) is true also meet only the third condition in (247), in contrast to the set-denotative rendering of the non-event-dependent interpretation which requires every context to meet the first or second condition (227)).

As we have seen, in event logic, the real objects of predication and

quantification are events rather than sets. The quantity of a set is affected only in so far as its members are participants in events. It should be emphasized that we do not expect that the definition of B^*C and B^*B ((207)) for a given context defines a corresponding event in that context. Suppose, as in sec. 4.4, that all critics in the given context are divided among local book clubs. On different days of the week, a different club will go on an outing at which the members who are present buy books for the club. The events of this context are the outings. According to the event-logical (244), the event-dependent interpretation of (204a) is true in this context if and only if each of the outings at which (at least) three good books were bought involved few critics, and the non-event-dependent interpretation is true if and only if all such outings involved all together few critics. The definitions of B^*C and B^*B cut across the events. Now in this context B^*C is the set of all critics who went on any of the outings, and B^*B is the set of all books bought on any of the outings. So defined, there is no event in this context of B^*C buying B^*B . It is not any of the individual outings. The domain of events, the outings, does not include one which all the others are parts of.

In other contexts, B^*C and B^*B might just happen to be the participants of an individual event of critics buying good books. Consider a domain of events that includes all the outings of the local book clubs but also some book-buying outings of the national organization to which all locals and their members belong. One of the national outings may have been attended by all and only the critics who went on local club outings, and the good books bought on the national outing may be all and only the good books bought on the local outings. Only in such circumstances do the event-logical

interpretations imply that all the critics buying good books are few or there were not (at least) three good books bought by critics. For in this case, all the critics who bought good books also bought good books in an individual event, the national outing, and all the good books bought by critics were also bought in the same individual event. Note however that the domain of events still does not include one which all the others are parts of. This is not the relationship between the national outing and the local outings.

As in sec. 3.5, we do not expect a domain of events to be closed under recombinations of their parts. What has happened across several outings is not itself another event in the domain quantified over in (244). Hence, we cannot expect the sets B^*C and B^*B as defined to correspond to an event in the domain. It is thus possible for contexts in which the event-logical interpretations are true to meet only the third condition in (247).

We have already seen what the set-denotative interpretations imply in this context or any other. The objects of predication and quantification are sets of individuals unrestricted by any relationship to events. Even in the narrower context in which just local outings are talked about, B^*C and B^*B , although not the participants of any one local outing, are in the domain of sets of individual objects, since it is closed under unions. Even in the narrower context the set-denotative interpretations of (204a) are true only if few critics bought good books or there were not (at least) three good books bought by critics.

4.9

Later sections consider in more detail how quantifying over sets of individuals, if allowed, must depend on quantifying over individual events. That discussion makes use of a logic in which one can freely talk about both sets and events. As in the set-denotative logic of sec. 2, it assumes a domain of sets of individual objects; but it also distinguishes a domain of individual events. It is at first assumed that sets of individuals, like individual objects themselves, can be involved in diverse events. We then have an $n+1$ -ary predicate wherever we had an n -ary predicate in the set-denotative logic, adding a place for individual events: in the extended logic " $\Phi(v_1, \dots, v_n, e)$ " will be true of n sets and an event e just in case " $\Phi(v_1, \dots, v_n)$ " in the set-denotative logic would be true at e . In all other respects, the extended logic follows the set-denotative logic. Thus, polyadic predicates are atomic relations (0.1), and plurality is treated by quantifying over sets of individuals according to clauses (15) and (16) in sec. 2.0.

The event place in the extended logic makes it possible for this logic to also avoid the unacceptable implications observed in sec. 4.6. Recall that it was shown that every set-denotative interpretation conforming to (189) results in unacceptable entailments for the sentences so interpreted if " Φ " expresses an increasing relation:

(189) $NP_1^{\text{non-increasing}} (NP^{\text{non-decreasing}})^* NP_2^{\text{non-decreasing}} \Phi,$
where an $NP^{\text{non-decreasing}}$ that is non-increasing is interpreted

only by (16b), as non-event-dependent.

The event place makes it possible for us to be certain that no " Φ " expresses an increasing relation when a sentence's interpretation conforms to (189). Note that " $E\Phi(x,y,e)$ " does not express an increasing relation in the extended logic although the corresponding " $\Phi(x,y)$ " may express one in set-denotative logic. As illustrated by the example in sec. 4.7, the existence of an event of critics buying good books in which c_1 bought b_1 and the existence of such an event in which c_2 bought b_2 does not entail the existence of an event in which $c_1 \cup c_2$ bought $b_1 \cup b_2$.

In eliminating the expression of increasing relations between sets of individuals, the position of the existential quantifier relative to the other quantifiers is crucial. Note that if E is a constant referring to a particular event, " $\Phi(x,y,E)$ " will express an increasing relation in the extended logic if " $\Phi(x,y)$ " does in the set-denotative logic. The reference to a particular event serves only to stipulate that the relation is about things that happened within E . Interpreting (204a), the extended logic may not assign the existential quantifier widest scope:

(248) * $Ee[\text{Few critics}(x)][(\exists)3 \text{ good books}(y)] \text{ critics}(x) \text{ bought good books}(y) \text{ at } E$

(249) $[\text{Few critics}(x)]Ee[(\exists)3 \text{ good books}(y)] \text{ critics}(x) \text{ bought good books}(y) \text{ at } E$

(250) $[\text{Few critics}(x)][(\exists)3 \text{ good books}(y)]Ee \text{ critics}(x) \text{ bought good books}(y) \text{ at } E$

By reasoning as in sec. 4.6, it can be shown that (248) attributes to (204a) an interpretation that has the truth conditions in (251):

(251) "few critics bought (at least) three good books" is true iff there is some event of critics buying books such that the critics were few or the

good books were not (at least) three. ⁶¹

There are other positions in which the existential quantifier over events should not appear if the extended logic is to assign only acceptable interpretations. Recall that the expressions that express increasing relations in the set-denotative logic include complex formulas, e.g., "x are in complete agreement on few world problems with y". In this example, the counterpart in the extended logic of " Φ " must occur within the scope of an existential quantifier over events. Thus the following scope assignment is unacceptable:

(252) *[Few Dems(x)][(Φ)3 Reps(y)][[few world problems(z)]Ee x are in
complete agreement on z with y at e]

" Φ " in (252) continues to express an increasing relation: suppose that there are not few world problems distributed among one or more events of complete agreement between $d_1 U d_2$ and $r_1 U r_2$. At each of these events, it is also true, as part of the larger agreement that exists, that d_1 is in complete agreement with r_1 and d_2 is in complete agreement with r_2 . Then, there are not few world problems among events of complete agreement involving d_1 and r_1 and there are not few world problems among events of complete agreement involving d_2 and r_2 .

The argument in sec. 4.6 demonstrated some unacceptable consequences of the expression of an increasing relation. The consequences affect all interpretations that conform to (189), whether NP_1 is event-dependent or not. Here we show that an increasing property, defined in (253), undermines

61. Compare the grammatical interpretation, the sum of plurals, which asserts that there is some event of critics buying good books with few critics and (at least) three good books. See sec. 4.7.

the set-denotative representation of just event-dependent interpretations.

(253) " Φ " expresses an increasing property if $\langle x \rangle \langle y \rangle (\Phi(x) \ \& \ \Phi(y)) \rightarrow \Phi(x \cup y)$.

Examples of increasing properties are "good students(x) are unprepared" and "critics(x) buy books". The set-denotative version of event-dependence is obtained from (16b), which applied to the quantifiers in (254) yields (255).

- (254) a. Few good students are unprepared
 b. Few critics buy books

- (255) a. $\text{Ar } \langle \text{good students}(r) \text{ are unprepared} \rightarrow \text{few good students}(r) \rangle$
 b. $\text{Ar } \langle \text{critics}(r) \text{ buy books} \rightarrow \text{few critics}(r) \rangle$

The dependence on events is represented indirectly by placing the quantifier "few N'" within the scope of the universal quantifier over sets. But, when " Φ " expresses an increasing property, the union of all sets that Φ is itself a set that Φ . The event-dependent interpretation of the examples cited are reduced to their non-event dependent interpretations:

- (256) a. $\text{Es } \langle \text{few good students}(s) \ \& \ \text{Ar } \langle \text{good students}(r) \text{ are unprepared} \rightarrow r \subseteq s \rangle \rangle$
 b. $\text{Es } \langle \text{few critics}(s) \ \& \ \text{Ar } \langle \text{critics}(r) \text{ buy books} \rightarrow r \subseteq s \rangle \rangle$

In the set-denotative logic, an event-dependent interpretation is inexpressible when " Φ " is an increasing property. In (255), its intended representation collapsed into the non-event-dependent interpretation; but in some cases where " Φ " is an increasing property, the representation of an event-dependent quantifier results in a logical impossibility. Thus, these representations of the sentences in (257) require the union of all sets that Φ to be exactly ten N' and each subset that Φ to be exactly ten N':

- (257) a. Exactly ten good students are unprepared
 b. Exactly ten critics buy books

- (258) a. $\text{Ar } \langle \text{good students}(r) \text{ are unprepared} \rightarrow \text{exactly ten good students}(r) \rangle$
 b. $\text{Ar } \langle \text{critics}(r) \text{ buy books} \rightarrow \text{exactly ten critics}(r) \rangle$

Quantifying over events can eliminate the increasing property. In the extended logic any interpretation of (254) and (257) according to (259) avoids the problems noted above.

- (259) [Q good students]-x Ee good students(x) are unprepared at e.
[Q critics]-x Ee critics(x) bought books at e.

In particular, interpreting the non-increasing quantifier by (16b) will result in an event-dependent interpretation and will escape being invalid:

- (260)a. Ar (Ee good students(r) are unprepared at e → few good students(r))
b. Ar (Ee critics(r) buy books at e → few critics(r))

- (261)a. Ar (Ee good students(r) are unprepared at e → exactly ten good students(r))
b. Ar (E critics(r) buy books at e → exactly ten critics(r))

The set-denotative logic does not have the necessary event quantifier. It must assign interpretations to the sentences of (204)–(206) and to (254) and (257) with unacceptable results. An extended logic can assign interpretations that lack the unacceptable implications; but we leave open for the moment how to avoid in a set-denotative logic interpretations like (248) and (252). We return to this question in sec. 5.3.

4.10

Both event logic and the extended set-denotative logic quantify over a domain of individual events. We have seen in the example of of secs. 4.4 and 4.8 and in the discussion of sec. 3.5 that it is not a general property of contextually-specific domains of events to be closed under recombinations of their parts. This feature of events in either logic is necessary to avoid the unacceptable interpretations of sec. 4.2 and 4.6 and those noted in the

previous section. But, if true, it would appear to invalidate the deductions based on increasing relations. For, in any given context, (195) will not be true, as its representations in the extended logic ((262)) and in event logic ((263)) show:

(195) These ten boys₁ ate these ten pies₁

Those ten boys₂ ate those ten pies₁

The twenty boys_{1U2} ate the twenty pies_{1U2}

(196) These ten boys₁ carried these ten cartons₁ home

Those ten boys₂ carried those ten cartons₁ home

The twenty boys_{1U2} carried the twenty cartons_{1U2} home

(262) [Er:these ten boys₁(r)] [Es:these ten pies₁(s)] Ee boys(r) ate pies(s) at

[Er:those ten boys₂(r)] [Es:those ten pies₂(s)] Ee boys(r) ate pies(s) at

[Er:the twenty boys_{1U2}(r)] [Es:the twenty pies_{1U2}(s)] Ee boys(r) ate pies(s) at

(263) [Ee: ate(e) OF(e, these ten pies₁)] INFL(e, these ten boys₁)

[Ee: ate(e) OF(e, those ten pies₂)] INFL(e, those ten boys₂)

[Ee: ate(e) OF(e, the twenty pies_{1U2})] INFL(e, the twenty boys_{1U2})

In a given context, the existence of an event of boys eating pies in which b₁ ate p₂ and the existence of an event of boys eating pies in which b₂ ate p₂ does not entail the existence in that context of an event of boys eating pies in which b_{1U2} ate p_{1U2}.

What then accounts for the intuitive validity of the deductions in (195) and (196)? We suggest that the premises and conclusion are not all about the same domain of events. Recall that the approach of earlier sections was to fix a particular context, that is, a particular domain of events, and then to

consider the conditions under which a sentence was true of that particular domain. The same approach will not account for the validity of (195) and (196). The deductions do not seem to be about one particular domain of events, and as we have seen they are not true of the events within any one domain if represented as in (262) or (263).

When there is no intended context at hand, we suggest that the premises and conclusion are thought of as true if they meet conditions like the one in (264):

(264) "These ten boys ate these ten pies" is true iff there is some context (domain of events) and some event in that context in which these ten boys ate these ten pies.

The intuitive validity of these deductions is accounted for if the premises and conclusion have the truth conditions schematically represented in (265). "ER" stands for "there is some context (domain of events)". It is not shown binding a variable but the quantifiers over events are understood as restricted to members of R.

(265) ERThese ten boys₁ ate these ten pies₁
 ERThose ten boys₂ ate those ten pies₁

 ERThe twenty boys_{1U2} ate the twenty pies_{1U2}

ER[Er:these ten boys₁(r)] [Es:these ten pies₁(s)] Ee boys(r) ate pies(s) at e
 ER[Er:those ten boys₂(r)] [Es:those ten pies₂(s)] Ee boys(r) ate pies(s) at e

 ER[Er:the twenty boys_{1U2}(r)] [Es:the twenty pies_{1U2}(s)] Ee boys(r) ate pies(s)

ER[Ee: ate(e) OF(e, these ten pies₁)] INFL(e, these ten boys₁)
 ER[Ee: ate(e) OF(e, those ten pies₂)] INFL(e, those ten boys₂)

 ER[Ee: ate(e) OF(e, the twenty pies_{1U2})] INFL(e, the twenty boys_{1U2})

Whenever there is one context with an event in which b_1 ate p_1 and another context with an event in which b_2 ate p_2 , there is a context with an event in which $b_{1 \cup 2}$ ate $p_{1 \cup 2}$. Such a context and event is obtained by considering what happened in the two original events to be one event in the new context. It is in the nature of the predicate "boys eat pies (e)" that the events can be combined to yield an event of boys eating pies. Thus, the validity of the deduction still depends on the predicate. Substituting "Democrats are in complete agreement with Republicans (e)" results in an invalid deduction, showing that a distinction between non-increasing and increasing predicates persists. The deduction also depends on our knowledge of the structure of events. Recall that different contexts are not different states of the world; they are just different ways to parse the world (or a relevant piece of it) into constituent events. The deduction appears valid because one reparses the world (partially) from one statement to the next.

The view suggested here thus reconciles the quantifying over events to avoid the unacceptable interpretations of sec. 4.2, 4.6 and 4.9 with the validity of deductions such as (195) and (196).

Note that we have assumed that sentences are sometimes intended to be true of a specific context and sometimes not, as required by the deductions above, where the premises and conclusions appear within the scope of "ER". This alternation recalls the discussion in sec. 3.5 where quantified sentences sometimes quantify over actual individuals, objects or events, and sometimes over possible individuals. One treatment of quantifying over possible individuals recognized a modal operator R that quantified universally over "reifications", each of which is, like the "contexts" of this discussion, an

alternative way of recombining the atoms making up the individuals. Thus the event-dependent interpretation of (145) had the representation in (147b) when quantifying over actual events, and the representation in (147a) when quantifying over possible events. The intended interpretation of "R" was "in any reification", that is, "in any way there could be events such that...".

(145) Twenty-five hogs fit into stalls
 "Whenever there is a fitting of hogs into stalls, twenty-five hogs fit into them."

(147)a. (possibles) $R[Ee \text{ fit}(e): \text{into}(e, 25 \text{ stalls})]$ INFL(e, 25 hogs)
 b. (actuals) $[Ee \text{ fit}(e): \text{into}(e, 25 \text{ stalls})]$ INFL(e, 25 hogs)

4.11

The preceding sections have shown that quantifying over sets, if it exists at all, must be restricted by a relationship to events. Sec. 4.2 showed that an existential quantifier over events must come between a non-increasing quantifier over sets and a decreasing one if they are separated only by increasing quantifiers, as in (153).

(153) $NP_1^{\text{non-increasing}} \langle NP^{\text{increasing}} \rangle * NP_2^{\text{decreasing}} \diamond$

Sec. 4.6 showed that any formula " \diamond " that expresses an increasing relation yields unacceptable interpretations if it is closed by quantifiers over sets as in (189).

(189) $NP_1^{\text{non-increasing}} \langle NP^{\text{non-decreasing}} \rangle * NP_2^{\text{non-decreasing}} \diamond,$

where an $NP^{\text{non-decreasing}}$ that is non-increasing is interpreted only by (16b), as non-event-dependent.

" \diamond " can be kept from expressing an increasing relation if it includes a place for events and an existential quantifier over events is appropriately placed

among the quantifiers of (189). In sec. 4.9, we also noted that unacceptable consequences of expressing an increasing property can be avoided by including a place for events.

In the next chapter, we examine more closely the extension to set-denotative logic that adds a domain of events alongside the domain of sets. We will attack those differences that remain separating set-denotative logic and its extension from event logic, showing that plurals are to be treated essentially by quantifying only over events.

Chapter 5

Events, sets and individuals

The extension to set-denotative logic proposes two independent domains. There is a domain of sets of individual objects, as in set-denotative logic, and there is a domain of individual events, with the properties discussed in sec. 3.4-3.5. The sets are assumed to relate to events in exactly the way individual objects themselves do. They can participate along with others or alone in one or more diverse events. As required by this extension, we have an $n+1$ -ary predicate wherever we had an n -ary predicate in the set-denotative logic, adding a place for individual events:

(266) " $\Phi\langle c_1, \dots, c_n, e \rangle$ " is true iff $\Phi\langle c_1, \dots, c_n \rangle$ in e .

A predicate " Φ " is true of \underline{n} sets and an event just in case the event is a Φ -ing in which the \underline{n} sets were related by Φ -ing.

In all other respects, the extended logic is set-denotative, especially in so far as the analysis of plurals is concerned. Thus, plurals are interpreted according to (15) and (16) as quantifiers over sets of individual objects, and a polyadic verb with \underline{n} NP arguments still expresses an atomic relation (see 0.1), although it now has $n+1$ places. The extension, by conceding the discovery of an extra argument and a new ontology, could in principle answer the objections of chapter 4 without conceding the rest of

event logic, if its rules of interpretation can avoid unacceptable assignments of scope to the event quantifier (see sec. 4.5 and 4.9.)⁶².

This chapter shows that there is essentially only quantification over individual events and over individual objects. As in event logic, the appearance of quantifying over sets of individual objects can be entirely derived from quantifying over the events in which individual objects participate. The expressive power of the extended logic to quantify over both sets and events independently must be restricted, eliminating the effects of quantifying freely over sets. The two sections that follow each support one of two characteristic features of event logic: the Davidsonian decomposition of polyadic predicates and the proscription against variables over sets. Sec. 5.1 shows a restriction on the expressive power of the extended logic whose effects on what can be expressed are, in event logic, a natural consequence of the Davidsonian decomposition; and sec. 5.2 shows that the set-denotative logic must be kept from expressing what the event logic does not express because of its proscription against variables over sets.

(267) $\exists e [Q'N'(y)] \phi(x,y,e)$

In sec. 5.1, we show that the extended set-denotative logic assigns unacceptable interpretations if it has formulas (267) expressing a property of sets that is true of a set c if there is an event e in which c has ϕ 'ed

62. This is done below by modifying (15) and (16) so that the clauses interpreting quantifiers will at the same time quantify over sets and events. The quantification over events thus hides behind the set quantification, for which we will have to remove the bound variable e . Cf. Hazen's modal language for quantifying over worlds, discussed on p. 83f.

[Q'N'] and remains true of c at e even if c is a proper subset of those participating in the event e in the role assigned to the x -th argument. To avoid the unacceptable interpretations, (267) must be false of c unless it is all of the event e 's participants in that role.

In event logic, it is the Davidsonian decomposition of the polyadic predicate that prevents the expression of a property of sets that depends on what a set is related to within an event. Let us allow variables over sets while assuming a Davidsonian decomposition of the predicate in (267). Then, Φ is essentially spelled out as in (268), where, for concreteness, we have assumed the particular theta roles assigned by "INFL" and "OF".

(268)
$$\text{Ee}[Q'N'(\gamma)] \text{ INFL}(e,x) \ \& \ V(e) \ \& \ \text{OF}(e,y)$$

Recall that the main "trick" of event logic is to infer a relation between sets from their participation in the same event. But, the inferred relation is true only of those sets that exhaust the event's participants. The property expressed in (268), even allowing the variables over sets, is true of a set c if and only if c are V -ers in some event in which [Q'N'] are V -ed. It does not imply that c has V 'ed [Q'N'] unless c is all the V -ers in the event. For the proper subsets of V -ers in the event, "[Q'N']" will not measure who they V 'ed. The Davidsonian decomposition, because it prevents the expression of a true relation between sets, prevents the expression of a property that describes what a set did in a proper subpart of an event.

In the extended set-denotative logic, sec. 5.1 will show that its atomic predicates must be so restricted that " $\Phi(\dots, c_k, \dots e)$ " is true only if c_k includes all of those participating in the event e in the role required of the k -th argument. Thus, for any predicate " Φ ", " $\Phi(\dots, c_k, \dots e)$ " and

" $\Diamond(c_1, \dots, d_k, \dots, e)$ " cannot both be true if c_k is not identical to d_k . Contrary to the initial assumptions surrounding (266), the extension of " \Diamond " is a function of events. If there is an n -tuple of sets c_1, \dots, c_n such that " $\Diamond(c_1, \dots, c_n, e)$ " is true, it is unique.

In sec. 5.2, we show an important difference between quantifying over individual objects and quantifying over sets. It is always possible to define a property on individual objects that is true of an individual if the events in his history meet certain conditions.

$$(269) \quad [Q'N'(y)]Ee \Diamond(x, y, e)$$

The property in (269), taking x to be a variable over individual objects, requires us to find for each individual $[Q'N']$ -many objects among the diverse events in which he has participated. Similar properties on sets, where x in (269) is a variable over sets, must however be excluded. We cannot allow a property on sets that considers their participation across several events. Contrary to what is expected in the extended logic, no property can exploit the fact that the participants are the same in two distinct events of which " $\Diamond(c, e_1)$ " and " $\Diamond(c, e_2)$ " are true. It is clear however that event logic does not have formulas to express what happened to a set across several events. It does not have variables over sets, and it therefore cannot export a quantifier over sets to include within its scope a quantifier over events, as such a formula would require. Sec. 5.2 shows that if there is to be at all a domain of sets, then nothing we say about them attributes to them a lifespan longer than one event. Having assumed an ontology of individuals and sets of individuals, it is peculiar that the sets need to be treated so

differently from the individuals themselves⁶³.

Sec. 5.1 and 5.2 together show that a predicate denotes a set only if it is all the participants of an event and talks about the set's activity only within a single event. Event logic explains this relationship between sets and events-- it is the only possible one--since there is no predication of sets of individuals. Sets are affected only indirectly as participants in the actual objects of predication, events:

(31) Three agents sold twenty-five buildings to two investors.

(32) Ee [e was a selling & e's sellers were three agents &
e's sellees were two investors & e's sold were twenty-five buildings]

5.1

As in earlier sections, we construct a particular context in which to evaluate the truth conditions of relevant sentences. It will be shown for the sentences in (270) and (271) that "marbles(r) fall(e) into slots(s)"⁶⁴ cannot be true of a set of marbles and a set of slots if these are proper subsets of the marbles and slots involved in e.

(270) Fewer than fifteen marbles (ever) fall into exactly ten slots.

(271) Exactly ten marbles (ever) fall into exactly ten slots.

The particular context concerns the operations of something like a pachinko

63. If true, then individuals are not identified with singleton sets but belong to a separate sort of object.

64. I adopt this notation for the n+1-ary predicates of the extended logic, see (266).

machine, a turn on which releases a random number of marbles. The marbles then fall into an array of columns held in wooden slots. The machine has fifteen slots, but on each turn marbles may fall into all or just some of them. In this context, the events are turns on the machine. We compare two sequences of events. The sequence in (272) contains an event in which twenty-five marbles fall into ten slots. In the sequence in (273), one turn results in twenty-eight marbles falling into thirteen slots, and on a later turn, ten marbles fall into ten slots. The depictions leave nothing out apart from other turns in the two sequences; the turns just described involve only those balls and slots shown.

(272) ..., [

2	3	2	3	2	3	2	3	2	3
1	2	3	4	5	6	7	8	9	10

] , ...

(273) ..., [

2	3	2	3	2	3	2	3	2	3	1	1	1
1	2	3	4	5	6	7	8	9	10	11	12	13

] , ...

..., [

1	1	1	1	1	1	1	1	1	1	1	1
1	2	3	4	5	6	7	8	9	10		

] , ...

We now consider whether (272) and (273) falsify (270) and (271) when these are asserted about the operations of the pachinko machine.

Both sentences are in fact falsified, whether interpreted as event-dependent or not, by (272). The turn it depicts is an event of marbles falling into exactly ten slots. It is a relevant event but it involves twenty-five marbles, exceeding the quantity for each such event allowed by the event-dependent interpretations and also exceeding the quantity allowed by the non-event-dependent interpretations to such events all together.

In contrast, the turns depicted in (273) do not falsify either the event-dependent or the non-event-dependent interpretations of (270) or

(271). The first turn is not a relevant event. It is not an event of marbles falling into exactly ten slots, since its marbles fell into thirteen slots. As required by the event-dependent interpretation of (271), the only depicted event of marbles falling into exactly ten slots involves exactly ten marbles, which are also fewer than fifteen as required by the event-dependent interpretation of (270). If no other marbles are involved in other events in the sequence in which marbles fall into exactly ten slots⁶⁵, then the non-event-dependent interpretation of (271) will also be true of (273). The non-event-dependent interpretation of (270) will also be true of (273) if the participants in such events are all together fewer than fifteen marbles.

In the extended logic for (270) and (271), (273) falsifies both their event-dependent and non-event-dependent interpretations. These are equivalent to (274) and (275)⁶⁶:

(274)(event-dependent) Ar (Ee[10! slots(s)](marbles(r) fall(e) fall into slots(s) → fewer than 15 marbles(r))

(non-event-dependent) Eu(fewer than 15 marbles(u) &
Ar (Ee[10! slots(s)](marbles(r) fall(e) fall into slots(s)) → rCu)
& Aw(Ar(Ee[10! slots(s)](marbles(r) fall(e) into slots(s)) → rCw) → uCw))

(275) (event-dependent):

Ar (Ee[10! slots(s)](marbles(r) fall(e) fall into slots(s)) → 10! marbles(r))

(non-event-dependent) Eu(10! marbles(u) &
Ar (Ee[10! slots(s)](marbles(r) fall(e) fall into slots(s)) → rCu)
& Aw(Ar(Ee[10! slots(s)](marbles(r) fall(e) into slots(s)) → rCw) → uCw))

65. Either there are no other events of this kind or the same ten marbles are involved in each of them.

66. For our purposes, the outcome is the same whether "exactly ten slots" is analyzed as event-dependent or not. I have therefore left its analysis unspecified in (274) and (275). It also does not change the outcome to change the relative scope between "exactly ten slots" and the event quantifier.

What falsifies these interpretations is in the first turn of (273). Let e_1 be this turn. Let m_{1-10} be all the marbles in slots one through ten, and let s_{1-10} be the slots one through ten. According to the extended logic ((266)), we have:

(276) "marbles(m_{1-10}) fall(e_1) into slots(s_{1-10})" is true in (273).

Note that the marbles of m_{1-10} fall into exactly ten slots. There are no other slots in e_1 that these marbles fall into. Thus, m_{1-10} is a set of marbles that in some event falls into exactly ten slots; but, its twenty-five marbles, exceeding the quantity allowed by any of the interpretations in (274) or (275), falsifies them all.

The first turn of (273), being an event of marbles falling into thirteen slots, is not a relevant event. But, some of its parts, if they were events, are counterexamples to (270) and (271). The extended logic imposes conditions on the parts of otherwise irrelevant events.

A simpler demonstration of the same point concerns only the event-dependent interpretation of (277):

(277) Exactly 250 Democrats are (ever) in complete agreement with exactly 200 Republicans.

Recall from earlier discussion that we have supposed that an agreement is complete only if agreement between individual Democrats and individual Republicans is the Cartesian product of the two parties. One cannot find a Democrat and a Republican that disagree. Suppose now that (277) has been true of each in a sequence of many sessions in Congress. In this context, where the events are the sessions, the event-dependent interpretation of (277) is true; but, the event-dependent interpretation according to the extended

logic is false:

(278) $\text{Ar } (\text{Ee}[200! \text{ Republicans}(s)](\text{Democrats}(r) \text{ are}(e) \text{ in agreement with Republicans}(s)) \rightarrow 250! \text{ Democrats}(r)$

In fact, every session falsifies (278). Let $d_{\langle 250}$ be a proper subset of the Democrats who are in complete agreement with exactly 200 Republicans at any one session, say e_1 . Note that every member of $d_{\langle 250}$ agrees with every one of the 200 Republicans. Therefore, "Democrats($d_{\langle 250}$) are(e_1) in complete agreement with exactly 200 Republicans" is true. The set $d_{\langle 250}$, which is not exactly 250 Democrats, is a counterexample to (278).

These examples, (270), (271) and (277), show that it is wrong to think of the event as just a location at which a number of sets may relate to other sets in the way required by the predicate's meaning. Instead, for any event e_1 , if e_1 is a Φ -ing, then there is exactly one n -tuple of sets, c_1, \dots, c_n such that " $\Phi(c_1, \dots, c_n, e_1)$ " is true. For each turn e in (272) and (273), there is exactly one set of marbles m and one set of slots s such that "marbles(m) fall(e) into slot(s)" is true. Similarly, the sets of Democrats and the sets of Republicans satisfying "Democrats(r) are(e) in complete agreement with Republicans(s)" are unique for each session in the context for (277). Of course, the unique sets always correspond to all the participants in the event, all the marbles falling into slots and all the slots marbles are falling into, etc. Under this restriction, proper subsets of an event's participants are not denoted by the predicate and therefore do not falsify the quantificational sentences.

5.1.1

Recall that what we have called the event-dependent interpretations is paraphrased by (279), (280) and (281):

(279) "{Always when/ whenever} marbles fall into exactly ten slots, fewer than fifteen marbles are in that fall"

(280) "{Always when/ whenever} marbles fall into exactly ten slots, exactly ten marbles are in that fall"

(281) "{Always when/ whenever} Democrats are in complete agreement with exactly 200 Republicans, exactly 250 Democrats are in that complete agreement."

In their event-dependent interpretations, the VPs of sentences (270), (271) and (277) are a restriction on a universal (or generic) quantifier over events, and the subject NP is left in the matrix predicate. The event-dependent interpretations should be distinguished from others that also appear to have a wide-scope universal quantifier over events or cases in the sense of Lewis (1975). They are distinguished at least by the the event quantifier appearing unrestricted by a constituent of the sentence or restricted by something other than the VP, such as an NP. For example, the interpretations of (271) and (277) (without "ever", see below) in which the event quantifier is unrestricted are paraphrased in (282) and (283):

(282)"Always, exactly ten marbles fall into exactly ten slots"

"It is always true that exactly ten marbles fall into exactly ten slots"

(283)"Always, exactly 250 Democrats are in complete agreement with exactly 200 Republicans"

"It is always true that exactly 250 Democrats are in complete agreement with exactly 200 Republicans"

(282) is falsified by any turn of the pachinko machine at which other than ten marbles fall into other than ten slots. The first turn in (273) does

falsify this interpretation but so does (284) where exactly ten balls fall into exactly one slot:

(284) ..., [1101], ...

Because the event quantifier is unrestricted, every event of marbles falling into slots is relevant, not just those involving exactly ten slots.

It is important to keep in mind that turns on the pachinko machine like (284) show that the extended logic's (274a) and (275a) cannot be taken to represent interpretations with unrestricted event-quantifiers either. For, although (284) falsifies such interpretations, it does not falsify (274a) or (275a). It is also possible for there to be a context in which the interpretation with an unrestricted quantifier is true but the extended logic's interpretations are false. If at every session of Congress without exception, exactly 250 Democrats are in complete agreement with exactly 200 Republicans, the interpretation with an unrestricted event quantifier is true, and (278) is false for the reasons cited.⁶⁷

67. The interpretation with an unrestricted event quantifier seems inaccessible when "ever" is included in (270), (271) and (277). This interpretation also seems more marginal in (270) where the subject quantifier is decreasing, "fewer than fifteen marbles". I do not know why "ever" has this effect, and I can only relate the marginality of an unrestricted event quantifier in (270) to an earlier observation in n. 49 sec. 4.3. that decreasing subject quantifiers are reluctant to enter into a sum of plurals interpretation. A sum of plurals is presumably what is required within the scope of the unrestricted event quantifier: every e is such that fewer than fifteen marbles fall into slots and exactly ten slots are fallen into by marbles.

As for "ever", I assume that like related items such as "any" (see Ladusaw(1979), Linebarger(1980) among others), it is, at least descriptively, a chameleon, appearing in some places as polarity-sensitive with existential force and in other places with a "free choice" interpretation. The non-event-dependent interpretations of both (270) and (271) are examples of the first environment: "ever" occurs within the scope of a non-increasing

5.2

In this section, it will be shown that sentences do not predicate of sets properties of the form in (285):

(285) $[Q N'_2(y)] Ee \phi(x,y,e)$

quantifier, "fewer than fifteen marbles" or "exactly ten marbles" and has existential force. In the event-dependent interpretations of both sentences, "ever" appears in its other environment, not within the scope of any affective element and allowing a "free choice" ("whenever..."). The question is then why "free choice" "ever" cannot occur as an unrestricted event quantifier.

Again, I can only point to perhaps related phenomena. Ladusaw observes that "free choice" "any" has only a non-event interpretation, evident in the contrast between (i) and (ii):

- (i) Any newcomer was welcomed
- (ii) Every newcomer was welcomed

Only (ii) can report the welcoming of every newcomer (members of a specific set). The contrast shows that properties of the predicate, the "specificity" of its aspect, condition the appearance of "any" in subject position. Perhaps the matrix predicate occurring with the unrestricted event quantifier, incorporating a sum of plurals, is aspectually "specific":

Ever(e) (exactly ten marbles(e) & marbles-fall-into-slots(e) & exactly ten slot

The data poses another problem for the description of "ever"'s distribution. The appearance of "free choice" "ever" in the event-dependent interpretation ((279) and (280)), although outside the scope of any other quantifier, is still sensitive to the type of quantifier in subject position. Thus, the following are not grammatical even if event-dependent:

- (iii) * The red marbles ever fall into exactly ten slots
- (iv) * Some twenty marbles ever fall into exactly ten slots

Compare (v) and (vi), which have "free choice" "any" interpretations despite subject quantifiers that do not license polarity items:

- (v) The hunters shot any bear over six feet tall.
- (vi) Some twenty hunters shot any bear over six feet tall.

Such a property is true of a set \underline{c} just in case there are $[Q N'_2]$ -many N'_2 among the various events in which \underline{c} has ϕ 'ed⁶⁸. This kind of property comprehends the activity of a set across several events. Although not predicated of sets, this same kind of property can be predicated of individuals, saying that \underline{x} , an individual, has been related by ϕ -ing at various events in the course of his life to $[Q-N'_2]$ -many N'_2 .

In event logic, the difference between individuals and sets is expected. Sets are not objects denoted by predicates. A set, unlike an individual, is not thought of as something that participates in various events.

We consider two cases, for which we suppose it were possible to express the quantificational closure of a property like (285):

$$(286) [Q N'_1(x)] [Q N'_2(y)] Ee \phi(x, y, e)$$

In the first case, a sentence would have an interpretation that is false in the given context, although its relevant acceptable interpretations are all true. In the second case, a sentence would have an interpretation that is true in the given context, although its relevant acceptable interpretations are all false.

The contexts that distinguish the true and false interpretations in both cases contain at least two different events with identical participants S which also involve different participants A_1 and A_2 :

$$(287) \quad \dots, S \text{---} A_1, \dots, S \text{---} A_2, \dots$$

68. " $[Q N'_2(y)]$ " is either a quantifier over individuals or sets. What is important is that " $[Q N'_2(y)]$ " provides for more than one individual or set, on each of which depends² the choice of an event (" Ee ").

S is a potential counterexample as a value for x in (286); it is not $[Q N'_1]$ -many. For the first case, where (286) would be a false interpretation among otherwise true ones, the context is one in which the union of A_1 and A_2 is $[Q N'_2]$ -many, but neither A_1 nor A_2 is. For the second case where (286) would be true and acceptable interpretations false, at least one of A_1 and A_2 is $[Q N'_2]$ -many, but their union is not.

5.2.1

The context for (288) shows that the sentence does not have interpretations that are the quantificational closures of the property "[Exactly ten amendments(y)]Ee senators(x) co-sponsored(e) amendments(y)", as in (289). Different interpretations are obtained by analyzing the quantifier "[Few senators(x)]" either according to (16b) as a non-event-dependent quantifier over sets or according to (16a), the set-denotative and extended logics' version of an event-dependent quantifier over sets. The property in (289) expressed by the formula within the scope of "[Few senators(x)]" is true of a set of senators if they have co-sponsored throughout legislative history exactly ten amendments.

(288) Few senators ever co-sponsored (in some session or another)
exactly ten amendments.

(289):

*[Few senators(x)] [10! amendments(y)] Ee senators(x) co-sponsored(e) amendments(y)

For the context depicted in (290), let S be a caucus of more than few senators, and let S_1, \dots, S_n be the non-empty, non-singleton⁶⁹ proper subsets

69. in order to be co-sponsors.

of S. We consider now a sequence of senatorial sessions at each of which exactly one amendment is sponsored. Suppose also that no amendment is sponsored more than once. The sponsors of the amendment in consecutive sessions are:

(290) $S_1, \dots, S_n, S, S_1, \dots, S_n, S, S_1, \dots, S_n, S, S_1, \dots, S_n, S, S_1, \dots, S_n, S,$
 $S_1, \dots, S_n, S, S_1, \dots, S_n, S, S_1, \dots, S_n, S, S_1, \dots, S_n, S, S_1, \dots, S_n, S.$

The events of this context correspond to the senatorial sessions. Caucus S has sponsored exactly ten amendments, distributed among ten distinct sessions. Also note that every senator in caucus S has been a co-sponsor in the course of (290) of more than ten amendments, since every senator in S is also a co-sponsor in some of the S_i sessions.

The acceptable interpretations of (288) in which "few senators" is not event-dependent are true in (290). These are shown in (291) and (292). The quantifier binds a variable over individuals and the matrix can express either of the properties shown.

(291) [Few senators(x)]Ee[10! amendments(y)] senators(x) cosponsored(e) amendments(y)
 where \underline{x} is a variable over individuals.

(292) [Few senators(x)][10! amendments(y)]Ee senators(x) cosponsored(e) amendments(y)
 where \underline{x} is a variable over individuals.

The property in (291) is true of a senator if he has been at some session part of a co-sponsorship of ten amendments. In (290), each session saw the co-sponsorship of only one amendment. There are therefore no senators satisfying the property in (291), and this interpretation of (288) is then true.

The interpretation in (292) is the one deserving closest comparison to

(289). It differs only in the values for x , which are individuals. The property in (292) is true of a senator if there are throughout legislative history exactly ten amendments of which he has been a co-sponsor. As noted above, the senators in (290) each co-sponsor more than ten amendments. Thus, none satisfies the property expressed in (292), and this interpretation is therefore true in (290).

The quantifier "[few senators(x)]" is not event-dependent in (289) if it is interpreted according to (16b), as in (293). The property closed by the quantifier is the same as the one in (292) except for the values of x . Instead of requiring that the individual senators who have this property are all together few senators, this interpretation requires that the sets of senators who have this property are all together few senators.

(293) E_s (few senators(s) &
 $Ax([10! \text{ amendments}(y)]E_e \text{ senators}(x) \text{ co-sponsor amendments}(y) \rightarrow xC_s)$
 & $Aw(Ax([10! \text{ amendments}(y)]E_e \text{ senators}(x) \text{ co-sponsor amendments}(y) \rightarrow xC_w) \rightarrow sC_w))$

This interpretation is false in (290). Caucus S is a counterexample. It is a set of more than few senators, and there are throughout the legislative history in (290) exactly ten amendments that caucus S has co-sponsored.

The sentence in (288) is ambiguous. In some of its interpretations, the quantifier "few senators" is clearly not within the scope of any other operator. These interpretations are plain assertions about the quantity of senators satisfying some property. These interpretations of (288) are all true in (290). But, one of these interpretations, namely that interpretation conforming to (289) in which "few senators" is a non-event-dependent quantifier over sets ((16b)), would be false in (290) if it were possible to express a property of sets such as the one in (289).

No other interpretation of the quantifiers in (289) corresponds to an acceptable interpretation of (288). The interpretation in (294) obtained by applying (16a) to "few senators" fails to be the event-dependent interpretation of (288).

(294) $\text{Ax}([10! \text{ amendments}(y)] \text{Ee senators}(x) \text{ cosponsor amendments}(y) \rightarrow \text{few senators}(x))$

The event-dependent interpretation of (288) is vacuously true in (290). Any event of co-sponsoring exactly ten amendments involves few senators, since there are no such events in (290), only co-sponsorings of just one amendment. As with the first interpretation conforming to (289), caucus S is a counterexample to (294). The interpretation represented by (294) is false in (290) because there is a set, S, that has co-sponsored exactly ten amendments over the course of one or more sessions but is not few senators.⁷⁰

We may conclude then that no interpretation of (288) is obtained from the quantificational closure of the property on sets defined above. Unlike the similar property of individuals, no interpretation of (288)'s predicate expresses a property true of a set of senators just in case there are exactly ten amendments among the various sessions at which that set has co-sponsored amendments.

70. In (288), the decreasing quantifier "few senators" and the adverb "ever" are meant to exclude that interpretation discussed in sec. 5.1.1 which contains an unrestricted event quantifier. Such an interpretation of (288) is paraphrased by "any event is an event of few senators co-sponsoring exactly ten amendments." Note that this interpretation would be falsified by every one of the sessions in (290), since none is an event in which ten amendments are co-sponsored. For this reason, (294) could not be taken to represent an interpretation with an unrestricted event quantifier, even if it were available to (288). (294) is falsified only by the sessions at which caucus S is the co-sponsorship.

5.2.2

In this case, the unacceptable interpretations resulting from the quantificational closure of a property like (285) are true in the given context, although the acceptable interpretations of the sentence are false. The property exemplifying (285) is the same as the one in sec. 5.2.1.:

(295) [Exactly ten amendments(y)]Ee senators(x) co-sponsored(e) amendments(y)

It is true of a set of senators \underline{x} just in case there are exactly ten amendments distributed among the sessions at which they were the co-sponsors. (296) is the sentence whose interpretations we consider.

(296) Fewer than eleven senators ever co-sponsored (in some session or another) exactly ten amendments

For the context depicted in (297), let S be a caucus of eleven senators, and let U be a group of eleven senators disjoint from S. U_1, \dots, U_{11} are the eleven proper subsets of U that contain ten members. In each of them, a different senator of U is absent. A_1, A_2 and A_3 are disjoint sets of exactly ten amendments each. Let c_1, \dots, c_{11} be eleven distinct individual amendments. (297) shows the sponsors and their amendments in consecutive sessions of the Senate.

(297) S-- A_1 , U_1 -- c_1, \dots, U_6 -- c_6 , S-- A_2 , U_7 -- c_7, \dots, U_{11} -- c_{11} , S-- A_3

The events again correspond to senatorial sessions. Caucus S has sponsored thirty amendments distributed among three sessions at which exactly ten were sponsored. Note that the senators in U have each been a co-sponsor in the course of (297) of exactly ten amendments. Every senator of U was absent at the co-sponsoring of one of the eleven amendments c_1, \dots, c_{11} but present for

the ten remaining, and he was a co-sponsor of no others.

Acceptable interpretations of (296) are all false in (297). Each session involving S is an event of co-sponsoring exactly ten amendments, and it involves eleven senators. The event-dependent interpretation in (298) is falsified by each of these events:

(298) $[Ae: \text{co-sponsor}(e) \text{ exactly ten amendments}][\text{fewer than eleven senators}(x)]$

The acceptable interpretations of (296) in which "few senators" is not event-dependent are shown in (299) and (300). The quantifier binds a variable over individuals and the matrix can express either of the properties shown.

(299):
 $[\text{Fewer than 10 senators}(x)][Ee[10! \text{ amendments}(y)] \text{ senators}(x) \text{ co-sponsored}(e) \text{ amendments}(y),$
where x is a variable over individuals.

(300):
 $[\text{Fewer than 10 senators}(x)][10! \text{ amendments}(y)]Ee \text{ senators}(x) \text{ co-sponsored}(e) \text{ amendments}(y),$
where x is a variable over individuals.

The property in (299) is true of a senator if he has been at some session part of a co-sponsorship of ten amendments. In (299), the senators of S have each been at such sessions. Together they are eleven, falsifying this interpretation of (296).

The interpretation in (300) is the quantificational closure of a property that differs from (295) only in being defined for individuals rather than sets. It is true of a senator if there are throughout legislative history exactly ten amendments of which he has been a co-sponsor. As noted above, the senators of U each co-sponsor in (297) exactly ten amendments. Since,

there are eleven of them, this interpretation of (296) is also false.

Now if it were possible for (296) to contain the expression of the property of sets in (295), then (296) would have interpretations that were true in (297). The interpretations in which "fewer than ten senators" is analyzed by (16a) or by (16b) are both true:

(301) [Few senators(x)] [10! amendments(y)] Ee senators(x) cosponsored(e) amendments

(302) Ax ([10! amendments(y)] Ee senators(x) co-sponsor amendments(y)
→ fewer than 10 senators(x))

(303) Es (fewer than 10 senators(s) &
Ax ([10! amendments(y)] Ee senators(x) co-sponsor amendments(y) → xCs)
& Aw (Ax ([10! amendments(y)] Ee senators(x) co-sponsor amendments(y) → xCw) → sCw))

None of the sets in (296) have the relevant property. Both interpretations are therefore vacuously true. That is, any set of senators co-sponsoring exactly ten amendments is fewer than eleven senators, and all such sets of senators are together fewer than eleven. The sets U_1, \dots, U_{11} have each co-sponsored only one amendment, and the set S has co-sponsored exactly thirty amendments. No other sets of senators in the context of (297)'s events can be considered to have co-sponsored amendments. Following sec. 5.1, "senators(x) co-sponsor(e) amendments(y)" denotes a set of senators, an event, and a set of amendments only if the set of senators and the set of amendments exhaust the senators and amendments participating in the event. The sets of senators exhausting their events in (296) are exactly S and U_1, \dots, U_{11} , and these sets do not falsify either (302) or (303).

Since no interpretation of (296) is true in (297), we may conclude that the property on sets (295) cannot be expressed, despite the similar property of individuals expressed in the interpretation in (300).

Sections 5.1 and 5.2 have shown that there is essentially no quantification over an independent domain of sets. If quantification over sets is assumed, sec. 5.1 shows that no predicate denotes a set unless it is all the participants in an event who fulfill some role (e.g., all marbles falling into slots or all slots marbles are falling into). There are no proper $n+1$ -ary relations where " $\Phi(c_1, \dots, c_n, e)$ " and " $\Phi(d_1, \dots, d_n, e)$ " are both true and some c_i is not identical to d_i . Any predicate is a function from events to n -tuples of sets. Sec. 5.2. shows that there must be some way to exclude the expression of properties that talk about a set's activities across several events. Although sets do participate in different events such that " $\Phi(s, r_1, e_1)$ " and " $\Phi(s, r_2, e_2)$ " may both be true, we must not form the property " $[Q N'(y)]Ee \Phi(x, y, e)$ ", which to be true of the set s depends on the size of $r_1 \cup r_2$. One can say of sets only what can be said of events.

5.3

In this section we introduce a new set-denotative logic, modifying the clauses (15) and (16) that interpret quantifiers. The new clauses quantify over events and sets at the same time, eliminating the need for a separate quantifier over events. But, to satisfy the restrictions required by this chapter, the sets will really just be shadows of the events. The new logic will also meet the objections of chapter 4, while remaining set-denotative in an important way.

The new logic is introduced for two reasons. The first is just to present an object that answers chapters 4 and 5 without being event logic. It will

help to collect the results of these chapters and to show what aspects of event logic they are evidence for and what aspects not. The second reason is of course to address what remains to distinguish it from event logic. This concerns standard assumption 0.1 about atomic polyadic predicates. The new logic preserves the formal syntax of set-denotative logic: the plural NPs are all quantifiers that bind variables in a polyadic atomic predicate.

(304) Increasing quantifiers.

- a. (undivided reference to a denotatum) "[Q N'] $\Phi(x)$ " is true iff for some event-indexed set $\langle c, i \rangle$, c is [Q N']-many, and " $\Phi(\langle c, i \rangle)$ " is true.
- b. (divided reference to denotata) "[Q N'] $\Phi(x)$ " is true iff for some event-indexed sets $\langle c_1, i_1 \rangle, \dots, \langle c_k, i_k \rangle, \dots$, the union of c_1, \dots, c_k, \dots is [Q N']-many and " $\Phi(\langle c_1, i_1 \rangle)$ " is true...and " $\Phi(\langle c_k, i_k \rangle)$ " is true....

(305) Non-increasing quantifiers.

- a. (event-dependent) "[Q N'] $\Phi(x)$ " is true iff every event-indexed set $\langle c, i \rangle$ is such that if " $\Phi(\langle c, i \rangle)$ " is true c is [Q N']-many.
- b. (non-event-dependent) "[Q N'] $\Phi(x)$ " is true iff the union of all sets c such that for some event i " $\Phi(\langle c, i \rangle)$ " is true is [Q N']-many.

The intuitive idea that characterizes clauses (304) and (305) is that they interpret sentences such as those in (306) as elliptical expressions of the sentences in (307).

(306) Ten critics bought twenty good books

Few critics jointly bought exactly ten good books

(307) Ten critics in some event(s) bought twenty good books in some event(s)

Few critics in some event(s) jointly bought exactly ten good books in some event(s)

The events indexing sets are the same events that appear in event logic or in the extension to set-denotative logic considered earlier. They have the properties described in sec. 3.4-3.5. The logical form of a sentence associates with each plural quantifier its own quantification over events and with each set its own event-index; but, it is assumed that one's knowledge of

events has the following effects on the meaning of any sentence. If any predicate " Φ " is true of an n-tuple of event-indexed sets, then the events indexing those sets are identical:

$$(308) \Phi(\langle c_1, i_1 \rangle, \dots, \langle c_n, i_n \rangle) \rightarrow i_1 = \dots = i_n$$

As with event logic and the earlier extension to set-denotative logic, we have just one event of Φ -ing. But, the extended logic's n+1-ary " $\Phi(c_1, \dots, c_n, e)$ " is replaced by the n-ary " $\Phi(\langle c_1, e \rangle, \dots, \langle c_n, e \rangle)$ ", copying e as an index on every set. Following sec. 5.1, one also knows that the sets related to any event are unique. Hence, (309) is true of any predicate and arbitrary sets and events:

$$(309) (\Phi(\langle c_1, e \rangle, \dots, \langle c_n, e \rangle) \ \& \ \Phi(\langle d_1, e \rangle, \dots, \langle d_n, e \rangle)) \rightarrow (\forall i: 1 \leq i \leq n) \ c_i = d_i$$

The requirements of sec. 5.2 are also met. It is not possible to express anything equivalent to the extended logic's (289), which is the quantificational closure of the property in (310) that requires of a set of senators that there be exactly ten amendments distributed among the events in which that set has co-sponsored amendments.

$$(310) [\text{exactly ten amendments}(y)] \ Ee \ \text{senators}(x) \ \text{co-sponsored}(e) \ \text{amendments}(y)$$

$$(289) *[\text{Few senators}(x)][\text{exactly ten amendments}(y)] Ee \ \text{senators}(x) \ \text{co-sponsored}(e) \ \text{amendments}(y)$$

The new logic has no equivalent to (289) because the interpretation of a quantifier is always construed with a hidden quantification over events. If, for example, "few senators" in (288) is interpreted first, according to (305b), (311) is obtained.

$$(288) \text{ Few senators co-sponsored exactly ten amendments}$$

$$(311) (288) \text{ is true iff the union of all sets } c \text{ such that for some event } i \text{ " $\langle \langle \text{senators}(c), i \rangle \rangle \text{ co-sponsored exactly ten amendments}$ " is true is few}$$

senators.

The only property of a set c that can be expressed by " $\langle \text{senators}(c), i \rangle$ co-sponsored exactly ten amendments" is one about c 's activity within the single event i . In terms of the extended logic, the resulting interpretation is equivalent to (312) rather than (289):

(312) $[\text{Few senators}(x)]Ee[\text{Exactly ten amendments}(y)] \text{senators}(x) \text{ co-sponsored}(\text{amendments}(y))$

The new logic does not allow for a separate, independent quantifier over events. As reflected in the equivalence of (312), the interpretations assigned by clauses (304) and (305) guarantee that an existential quantification over events separates set quantifiers. The equivalent of (289) is never assigned. 71

71. There is an alternative to (304) and (305) that is closer to the extended logic. It adopts the extended logic's $n+1$ -ary predicates " $\Phi(x_1, \dots, x_n, e)$ " and the constraints of sec. 5.1 on their truth conditions; but in the logical form assigned to any natural language sentence, the event variable e is always free. The logical form is interpreted according to (313) and (314). Note that the quantification over events introduced by the first quantifier to be interpreted is the one that assigns values to the free event variable. The quantification over events introduced by quantifiers with narrower scope is vacuous.

(313) Increasing quantifiers.

a. (undivided reference to a denotatum) " $[Q N'] \Phi$ " is true iff for some set c and some event i , c is $[Q N']$ -many, and " $\Phi[c, i]$ " is true.

b. (divided reference) " $[Q N'] \Phi$ " is true iff for some sets c_1, \dots, c_k, \dots , and some events i_1, \dots, i_k, \dots the union of c_1, \dots, c_k, \dots is $[Q N']$ -many, and " $\Phi[c_1, i_1]$ " is true...and " $\Phi[c_k, i_k]$ " is true....

(314) Non-increasing quantifiers.

a. (event-dependent) " $[Q N'] \Phi$ " is true iff every set c is such that if for some event i c is involved in i and " $\Phi[c, i]$ " is true then c is $[Q N']$ -many.

Interpretation according to (304) and (305) also escapes the problems of chapter 4. The argument of sec 4.2, summarized in terms of the extended logic in sec 4.5, showed that no sentence should be assigned an interpretation equivalent to either (186) or (187). An existential quantifier over events must come between the non-increasing NP_1 and the decreasing NP_2 as in (188):

(186) $*NP_1^{\text{non-increasing}} (NP^{\text{increasing}})^* NP_2^{\text{decreasing}} Ee \Diamond(v_1, v^*, v_2, e)$

(187) $*Ee NP_1^{\text{non-increasing}} (NP^{\text{increasing}})^* NP_2^{\text{decreasing}} \Diamond(v_1, v^*, v_2, e)$

(188) $NP_1^{\text{non-increasing}} \dots Ee \dots NP_2^{\text{decreasing}} \Diamond(v_1, v^*, v_2, e)$ ⁷²

(154) a. Few critics bought few good books

Recall the an interpretation of (154a) in the extended logic according to (186) would imply that, if all critics are more than few, there are many good books that they were all involved in buying (in the course of one or more events). An interpretation according to (187) would have a similar unacceptable implication with respect to some particular event. But, (154a) interpreted according to (188) implies only that, if all the critics are not few, there is no event of buying few good books which they were all involved in.

As noted above, when we consider the interpretations in the event logic equivalent to those derived from clauses (304) and (305), we see that these clauses always put an existential quantifier between set quantifiers,

b. (non-event-dependent) "[Q N'] \Diamond " is true iff the union of all sets c such that for some event i c is involved in i and " $\Diamond[c, i]$ " is true is [Q N']-m

72. The position of the event quantifier with respect to the increasing quantifiers NP^* is irrelevant.

deriving an equivalent to (188) but excluding (186) and (187).

In sec. 4.6, it was shown that every set-denotative interpretation conforming to (189) results in unacceptable entailments for the sentences so interpreted if " \diamond " expresses an increasing relation:

(189) NP_1 non-increasing $\langle NP$ non-decreasing $\rangle^* NP_2$ non-decreasing \diamond ,
where an NP non-decreasing that is non-increasing is interpreted only by (16b), as non-event-dependent.

(204) a. Few critics bought (at least) three good books

Such an interpretation of (204a) would, for example, imply that few critics bought good books or there are not (at least) three good books bought by critics.

In sec. 4.9, where the argument of sec 4.6 is discussed in terms of the extended logic, it is pointed out that the unacceptable entailments of (189) are avoided if an existential quantifier over events intervenes between NP_1 and NP_2 . But, clauses (304) and (305) assign only interpretations which are equivalent to those where an existential quantifier intervenes.

Sec 4.9 also pointed out that the set-denotative version of some event-dependent quantifiers assigns unacceptable interpretations that are always false, when these quantifiers close increasing properties or properties that are true of the subsets of any set of which they are true.
(257) a. Exactly ten good students are unprepared

Assuming "be unprepared" in (257a) is such a property, the set-denotative version of (257a)'s event-dependent interpretation is always false. It requires any set of unprepared students to be exactly ten, which cannot be

true of a set and proper subset. The unacceptable interpretation is avoided whenever an existential event quantifier comes between the property and the set quantifier. According to (305a), any set c is few good students, if at some event i , c is unprepared. Following from (309), no other set could be unprepared at i . The property of event-indexed sets "be prepared($\langle x, i \rangle$)" is not increasing nor true of the subsets of x at i . Hence, the unacceptable interpretation is avoided.

Chapter 6

Quantifying over sets, events and individual objects and the syntax of logical form

Event logic, the logic based on clauses (304) and (305), and the alternative in n. 71 all meet the constraints on interpreting plurals discussed in chapters 4 and 5. The last two preserve the syntax of set-denotative logic. Plurals are quantifiers that bind in polyadic atomic predicates variables whose values are (event-indexed) sets. Recall from sec. 3.2 the characteristic feature of set-denotative syntax: the atomic polyadic predicate "V" always appears with a full valence of argument positions. In interpreting a sentence, any (sub)formula that contains "V" contains a place for every NP in the sentence. The sum of plurals, event-dependent and non-event-dependent interpretations are all obtained in the new logic from (315) and in the alternative of n. 71 from (316):

(315) $[Q N'(\langle X, i \rangle)] \diamond [NP_j \dots NP_k V(\langle X, i \rangle, \dots)]$

(316) $[Q N'] \diamond [NP_j \dots NP_k V(X, e, \dots)]$

The different interpretations are derived from the clauses that interpret "[QN']", (304) and (305) in the new logic, and (313) and (314) in n. 71. Note that the events relevant for all of these interpretations are events i in which $\diamond(\langle X, i \rangle)$ for some value of the set variable X (or events e in which $\diamond(X, e)$ for some value of x). Thus, the sum of plurals interpretation says

essentially that some event in which for some $C \in \langle\langle C, i \rangle\rangle$ is such that C is $[Q N']$. Similarly, the event-dependent interpretation of (315), for example, says that any event in which some $C \in \langle\langle C, i \rangle\rangle$ is such that C is $[Q N']$. The non-event-dependent interpretation says that the union of all such sets C , for which there is an event in which $\phi(\langle C, i \rangle)$ is $[Q N']$. For all of these interpretations, a relevant event must satisfy a formula " $\phi(\langle X, i \rangle)$ " in (315) (or " $\phi(X, e)$ " in (316)) that has a place for all the NPs in the sentence. In particular, it has a place, X , bound by " $[Q N']$ ".

In contrast, interpretation in event logic uses formulas, " $\phi(e)$ " in (62)–(64) on p. 43, that contain " V " but do not contain places (theta roles) for all the NPs in the sentence. In deriving the sum of plurals, event-dependent and non-event-dependent interpretations, event logic uses three factors like those in (317): the quantifier " $[Q N']$ ", its theta role (which in (317) is the theta role assigned to the subject, " $INFL(e, \alpha)$ "), and the remainder of the sentence " $\phi(e)$ ", which expresses a property of events. It contains " $V(e)$ ", remaining NPs and their theta roles; but, it does not contain a place or theta role bound by " $[Q N']$ ".

(317) $[Q N'], \quad INFL(e, \alpha), \quad \phi[V(e) R_j(e, NP_j) \dots R_k(e, NP_k)]$

In event logic, the sum of plurals says that some event e that $\phi(e)$ is such that $INFL(e, [Q N'])$. Similarly, the event-dependent interpretation says that any event e that $\phi(e)$ is such that $INFL(e, Q N')$. And, somewhat more indirectly (see (64c)), the non-event-dependent interpretation says that $[Q N']$ -many individuals are among $INFL$ -ers in events e that $\phi(e)$. Crucially, a relevant event for any of these interpretations satisfies the formula " $\phi(e)$ ", which, unlike its counterpart in set-denotative logic, has no place, X , bound

by "[Q N']".

To argue against the set-denotative syntax, we need to bring in how quantifying over sets and events interacts with quantifying over individuals. In particular, we will consider how the set-denotative formula " Φ " in (315)–(316) and its counterpart in event logic, the formula " Φ " in (317), are interpreted when they contain a quantifier over individual objects. Thus, in the new logic, if " Φ " in (315) contains a quantifier over individual objects "[Q'y: N'(y)]", it looks like (318); and in the alternative of n. 71, such a " Φ " looks like (319). These are to be compared with the event logic's " Φ " when it contains a quantifier over individual objects, as in (320):

(318) ... \bullet [[Q'y: N'(y)]...V(X,i),y,...)]

(319) ... \bullet [[Q'y: N'(y)]...V(X,e,y,...)]

(320) ... \bullet [V(e) [Q'(y,e): N'(y)]...R(e,y)...]

Note that in the set-denotative logics, an event is relevant for interpretations based on (318) or (319) just in case it is an event in which some C has V...-ed each of [Q'N']-many individual objects. In event logic, an event relevant for interpretations based on (320) is one in which simply [Q' N']-many individual objects have each been V...-ed. It does not require that there be some C in the event to which the individual objects are all related. The occurrence of the variable X in " Φ " thus imposes an additional condition on relevant events. We will find that this results in unacceptable interpretations whenever " Φ ", as in (318) and (319), also contains a quantifier over individual objects. Set-denotative syntax fails because the atomic predicate "V" must always appear with a place for X. Sec. 6.1 begins

the argument of this paragraph. In the rest of this section, we review some interpretations that require variables over individual objects and discuss how their use affects the statement of truth conditions for atomic predicates.

In earlier chapters, the discussion of the event and set-denotative logics has considered for the most part just those aspects treating the problem that interpretations with plurals are not reducible to predications of only individual objects. In addition to quantifying over sets and/or events, these proposals also recognize those interpretations that call for the more familiar quantifiers that bind variables in predicates denoting individual objects. Recall from sec. 5.2 that (288), assuming "few senators" has wide scope, may have either of the interpretations in (291) and (292).

(288) Few senators ever co-sponsored (in some session or another) exactly ten amendments.

(291) [Few senators(x)]Ee[Exactly ten amendments(y)] senators(x) co-sponsored(e) amendments(y),
where x is a variable over individuals.

(292) [Few senators(x)] [Exactly ten amendments(y)] Ee senators(x) co-sponsored(e) amendments(y),
where x is a variable over individuals.

(291) stands for that interpretation where "exactly ten amendments" measures the individual events. It is about events of co-sponsoring exactly ten amendments, asserting that few senators were co-sponsors in such events. The resources of the new logic (and the alternative in n. 71) are adequate for this interpretation. It is obtained from quantifying over event-indexed sets that satisfy the formula " $\langle X, i \rangle$ co-sponsored exactly ten amendments". Interpreting "few senators" according to clause (305b), (288) is true iff the union of all sets with events in which they co-sponsored exactly ten

amendments is few senators. The atomic predicate is a relation on event-indexed sets as shown in (321):

(321) [Few senators($\langle X, i \rangle$)] [10! amendments($\langle Y, j \rangle$)] senators($\langle X, i \rangle$) co-sponsored amendments($\langle Y, j \rangle$)

It is the interpretation represented in (292) that calls for individual variables in addition to variables for events and sets. In this interpretation, "exactly ten amendments" measures the individual's activity across whatever events he has participated in. Any senator must be among few senators if there are exactly ten amendments, distributed among the events, which he co-sponsored. This interpretation requires an individual variable x and an atomic relation between individuals and event-indexed sets:

(322) [Few senators(x)] [10! amendments($\langle Y, j \rangle$)] senator(x) co-sponsored amendments($\langle Y, j \rangle$)⁷³

The formula within the scope of "[few senators(x)]" is a property about the activities of an individual senator. Note that the atomic predicates in (322) and (321) are not, strictly speaking, the same; but one assumes that they are related systematically, as reflected in their truth conditions given in (323) along with the truth conditions for other combinations of individual and event-indexed set variables. Constants and variables in capital letters are for sets, and those in lower case are for individuals:

(323) a. "co-sponsor($\langle C, i \rangle, \langle D, j \rangle$)" is true iff
i. (relational structure) C co-sponsor* D , and
(event structure) ii. $i=j$ and C co-sponsor* D at i , and
iii. for all sets X, Y , if X co-sponsor* Y at i , then $X \subseteq C$ and
b. "co-sponsor($c, \langle D, j \rangle$)" is true iff
i. (relational structure) $\{c\}$ co-sponsor* D , and

73. Note that "[few senators(x)]" is a standard quantifier over individuals that does not quantify over events at the same time.

- (event structure) ii. $\langle c \rangle$ co-sponsor* D at j, and
 iii. for all sets X,Y, if X co-sponsor* Y at j, then YCD.
- c. "co-sponsor($\langle C,i \rangle$,d)" is true iff
 i. (relational structure) C co-sponsor* (d), and
 (event structure) ii. C co-sponsor* (d) at i, and
 iii. for all sets X,Y, if X co-sponsor* Y at i, then XCC.
- d. "co-sponsor(c,d)" is true iff $\langle c \rangle$ co-sponsor* (d) ⁷⁴

In the clauses labelled "relational structure", the abbreviation "co-sponsor*" stands for whatever non-logical axioms spell out what who did to whom.⁷⁵ The relation between sets that they define is the same as the one which was considered by itself sufficient in the original set-denotative logic without events. The other clauses in (323) accomodate the relationship to events required by preceding sections. ⁷⁶ As (323b-d) show, a predicate's denotation of individuals is not restricted by the relationship

74. In the alternative of n. 71, we have:

- (324) a. "co-sponsor(C,D,e)" is true iff
 i. (relational structure) C co-sponsor* D, and
 (event structure) ii. C co-sponsor* D at e, and
 iii. for all sets X,Y, if X co-sponsor* Y at e, then XCC and
- b. "co-sponsor(c,D,e)" is true iff
 i. (relational structure) $\langle c \rangle$ co-sponsor* D, and
 (event structure) ii. $\langle c \rangle$ co-sponsor* D at e, and
 iii. for all sets X,Y, if X co-sponsor* Y at e, then YCD.
- c. "co-sponsor(C,d,e)" is true iff
 i. (relational structure) C co-sponsor* (d), and
 (event structure) ii. C co-sponsor* (d) at e, and
 iii. for all sets X,Y, if X co-sponsor* Y at e, then XCC.
- d. "co-sponsor(c,d,e)" is true iff $\langle c \rangle$ co-sponsor* (d) at e.

75. They would, for example, require that C sponsor D, and that at least two individuals a and b were such that $\langle a,b \rangle$ sponsor D.

76. The presentation in (323) is not meant to suggest that the lexical entry for every predicate must stipulate the event structure clauses. These clauses are presented in (323) just to make the truth conditions explicit.

to events restricting the denotation of sets. Any individual can meet the conditions in (323b-d), although his event contains other participants in the same role, in contrast to what sec. 5.1 demonstrated is required of sets. Also, quantifiers that bind individual variables have their standard interpretations; they do not quantify simultaneously over events. Thus, it is possible to express a property of individuals that holds across events. Again, this is in contrast to the restriction on properties of sets discussed in sec. 5.2.

We cite another example of the need for individual variables. Sec. 4.4 and 4.8 discuss the interpretation of (204d) in a particular context in which all the critics are divided up among book clubs. On different days of the week, a different club goes on an outing at which the members who are present buy books for the club. The events are the outings.

(204) d. Few critics bought three good books

(325) [Few critics($\langle X, i \rangle$)] [three good books($\langle Y, j \rangle$)] critic($\langle X, i \rangle$) bought
good books($\langle Y, j \rangle$)

The event-dependent interpretation of (204d)⁷⁷ is true in this context if every outing at which three books were bought involved few critics, and its non-event-dependent interpretation⁷⁸ is true if such events involved all together few critics. These interpretations, like (321), exemplify the dependence of a quantifier on an event-indexed set variable. It is possible that no one critic was a buyer of a book, doing all the labor required, at any of the relevant events. The critics may have been specialized finders,

77. obtained from (305a) applied to "[Few critics($\langle X, i \rangle$)]" in (325)

78. obtained from (305b) applied to "[Few critics($\langle X, i \rangle$)]" in (325).

appraisers, negotiators, or financiers. Of course, (204d) also has an interpretation quite apart from what can be obtained from clauses (304) and (305). The most familiar scope interactions require an individual variable: any critic is among few if he has bought three good books:

(326) [Few critics(x)][three good books(<Y,j>)] critic(x) bought good books(<Y,j>
or [Few critics(x)][three good books(y)] critic(x) bought good books(y)

This interpretation concerns what the individual bought for himself on his own. The denoted individual fulfills all roles that several individuals can specialize in. This is to be expected from the schema for denoting individuals, of which (323) is one instance and (327) another, for whatever must done by the set X according to "X buy* Y" is the burden of the singleton {c} in (327b) and (327d):

(327) a. "buy(<C,i>,<D,j>)" is true iff
i. (relational structure) C buy* D, and
(event structure) ii. i=j and C buy* D at i, and
iii. for all sets X,Y, if X buy* Y at i, then XCC and YCD.
b. "buy(c,<D,j>)" is true iff
i. (relational structure) {c} buy* D, and
(event structure) ii. {c} buy* D at j, and
iii. for all sets X,Y, if X buy* Y at j, then YCD.
c. "buy(<C,i>,d)" is true iff
i. (relational structure) C buy* {d}, and
(event structure) ii. C buy* {d} at i, and
iii. for all sets X,Y, if X buy* Y at i, then XCC.
d. "buy(c,d)" is true iff {c} buy* {d}

The systematic relationship among the predicates within each of (323) and (327) could be formalized in terms of predicate functors that operated on predicates denoting (event-indexed) sets to yield predicates denoting individuals. Instead of representing this type of functor explicitly, we will just let its application be recorded in the change of variables. For

us, it is sufficient to observe that in the interpretations represented by (322) and (326), the interaction of the quantifiers calls for individual-variables and quantifiers over individuals, and therefore some way for the predicate to denote individuals.⁷⁹

6.1

We now consider how quantifying over individuals interacts with quantifying over sets in the new logic (or in any set-denotative logic). Plurals are always quantifiers that bind variables in polyadic atomic predicates. In some cases, the values of variables are (event-indexed) sets and in others, the values are individual objects.

We first observe that some interpretations, if they are to be represented in the new logic, will require there to be atomic predicates that express relations between individuals and (event-indexed) sets. These predicates are of the form $V(\dots, \langle X, i \rangle, \dots, y, \dots)$, with at least one place for a variable over event-indexed sets and one place for a variable over individual objects. The interpretations that require these predicates fall into two cases. In the first case, the quantifiers binding variables over individual objects include within their scope the quantifiers that bind variables over (event-indexed) sets. In the second case, a quantifier over individual objects does not include within its scope at least one of the quantifiers

79. Cf. Scha's (1981) star (*) operator, a functor from predicates denoting sets to predicates denoting singletons, and (52) in sec. 3.3.

over (event-indexed) sets. Note that an interpretation represented by a logical form that is the closure of (318) falls into the second case.

An example of the first case is the interpretation of sentences (31) and (328) that is represented in the event logic by (60c) from chapter 3.

(31) Three agents sold twenty-five buildings to two investors.

(328) Three agents each sold twenty-five buildings to two investors.

(60) c. $NP[3\langle x, e \rangle \text{ agent}(x)] \text{ INFL}(e, x) \text{ sell}(e) \text{ OF}(e, 25 \text{ bldgs}) \text{ to}(e, 2 \text{ invstrs})$

"Three agents each sold twenty-five buildings and sold them to two investors"

In this interpretation, a sum of the plurals "twenty-five buildings" and "two investors" describes what each agent did. In the new logic, the sum of the plurals requires them to bind event-indexed set-variables, and they are interpreted according to clause (304a) on p. 164.⁸⁰ Since, this is to express a property of the individual agents, "three agents" has widest scope and binds a variable over individuals:

(329) $[3x:\text{agnt}(x)][25 \text{ bldgs}(\langle y, i \rangle)][2 \text{ invstrs}(\langle z, j \rangle)] \text{ agnt}(x) \text{ sold bldgs}(\langle y, i \rangle) \text{ to invstrs}(\langle z, j \rangle)$

Note that in (329) that atomic predicate contains both types of variable, and the quantifier over individuals includes within its scope the quantifiers over sets.

80. A better example is (i):

(i) Three gerrymanderers (each) turned ten neighborhoods into eight electoral districts.

Its truth in the following situation shows plainly that "ten neighborhoods" and "eight electoral districts" must both bind set variables. What each gerrymanderer has done is divide each of his ten neighborhoods into eighths such that each of his eight electoral districts is made up of ten parts-- an eighth from each of the ten districts.

The example illustrating the second case of mixing individual and set variables requires the scope to be reversed: the plural quantifier over individuals is included within the scope of a quantifier over sets. This is required for the interpretation of (31) and (330) represented in event logic by (60e) from chapter 3:

(330) Three agents sold twenty-five buildings to two investors each.

(60)e._{up} [Ee sell(e):[25(y,e) bldg(y)][OF(e,y) to(e,2 invstrs)]] INFL(e, 3 agnts)

"Three agents together sold twenty-five buildings each to two investors"

In this interpretation, there is a scope relation between "twenty-five buildings" and "two investors". Twenty-five buildings were each sold to two investors. The plural "twenty-five buildings" must therefore bind a variable over individual objects and include within its scope "two investors", which may bind a variable of either type. According to this interpretation, the state of affairs in which twenty-five buildings were each sold to two investors was brought about by three agents' selling; but the interpretation leaves open which agents were responsible for which sales. Recall that in event logic, the matrix logical form (60e) is that of a sum of plurals: some event of selling's sellers are three agents. The scope relation between "twenty-five buildings" and "two investors" elaborates the description of that event of selling. In event logic, one finds formulas with only an event variable free, as in the restriction on the event quantifier:

(331)...[Ee sell(e):[25(y,e) building(y)][OF(e,y) to(e,2 investors)]]...

Note that (331) is an instance of " $\Phi(e)$ " in (320), and (60e) is an instance of an interpretation obtained from factors such as those in (317).

As we have seen, the set-denotative counterpart to the property of events

in (331) is a property of event-indexed sets in the new logic or a relation on sets and events in the alternative of n. 71. In the new logic, the properties in (332) are true of a set of agents who are the sellers in an event in which twenty-five buildings were each sold to two investors.

- (332) a. $[25x:\text{bldg}(x)][2y:\text{invstr}(y)] \text{ agnts}(\langle Z,i \rangle) \text{ sold bldg}(x) \text{ to invstr}(y)$
 b. $[25x:\text{bldg}(x)][2 \text{ invstrs}(\langle Y,j \rangle)] \text{ agnts}(\langle Z,i \rangle) \text{ sold bldg}(x) \text{ to invstrs}(\langle Y,j \rangle)$

The formulas in (332) are instances of (318), and are thus among those that will be found to result in unacceptable interpretations. Nevertheless, closing one of these formulas by "three agents" and interpreting it according to (304a) is the only way to even approximate in the new logic the interpretation in (60e):

- (333) a. $[3 \text{ agnts}(\langle Z,i \rangle)][25x:\text{bldg}(x)][2y:\text{invstr}(y)] \text{ agnts}(\langle Z,i \rangle) \text{ sold bldg}(x) \text{ to invstr}(y)$
 b. $[3 \text{ agnts}(\langle Z,i \rangle)][25x:\text{bldg}(x)][2 \text{ invstrs}(\langle Y,j \rangle)] \text{ agnts}(\langle Z,i \rangle) \text{ sold bldg}(x) \text{ to invstrs}(\langle Y,j \rangle)$

Note that the two cases, (329) and (333), which simply reverse the scope between the quantifier over individuals and the quantifier over event-indexed sets, exemplify the kind of scope interaction that is expected if one assumes that there are atomic predicates with both types of variables and quantifiers that bind them.

We will now show in sec. 6.2 that logical forms in the new logic that contain properties of event-indexed sets as in (334) assign unacceptable interpretations. These are unacceptable interpretations that emerge from the interaction of just one event-indexed set variable and one variable over individual objects. Similar remarks would show the same thing for (335) in the alternative of n. 71.

(334) $[[Q'y:N'(y)] \vee (X,i),y)]$

(335) $[[Q'y:N'(y)] \vee (X,e,y)]$

This section will also show how event logic avoids the unacceptable interpretations, because its counterpart to (334) has the form in (336):

(336) $[[V(e) Q'(y,e):N'(y)] R(e,y)]$

We then show in sec. 6.3 that the interpretation in (60e) is in fact not represented by the new logic's (333). Again, similar remarks would serve to make the same point about the alternative in n. 71.

Recall that we have assumed the truth conditions of atomic predicates in set and individual variables to conform to a schema illustrated by (323) and (327). In sec. 6.4, it will be shown that there is no way out for the new logic (or any set-denotative logic) by changing the schema for atomic predicates or by changes in the clauses (304) and (305) interpreting quantifiers. We will consider here the possibility mentioned in sec. 3.2, p. 50, that Davidsonian decomposition, affecting what has been labelled "relational structure" in (323) and (327), applies only to the lexical interpretation of atomic predicates. Such changes that would eliminate the unacceptable interpretations of sec. 6.2 and allow the interpretation in (60e) to be represented would make it impossible to represent the interpretation in (60c). Recall that (60c) is an example of the first case of mixing set variables with variables over individual objects, in which the quantifier over individuals includes within its scope the quantifiers over (event-indexed) sets.

The line of argument developed in the following sections proceeds from the assumption that the closure of a property of event-indexed sets ((318)) is a

well-formed logical form. Perhaps, there is a syntactic constraint, ruling out our second case of mixed variables, that prohibits a quantifier over event-indexed sets from including within its scope a quantifier over individual objects. If it exists, the logical forms in sec. 6.2 that result in unacceptable interpretations will simply be ill-formed; but, the new logic will then fail to represent even approximately the interpretation in (60e), since its only possible logical forms, (333), will also be ill-formed. Against a new logic considered to have such a syntactic constraint, the existence of (60e) is thus crucial evidence for the syntax of event logic. We can then summarize this chapter as follows: if set-denotative syntax is regular, then it incorrectly represents the interpretation in (60e) and it assigns the unacceptable interpretations discussed in sec. 6.2. If there is an ad hoc constraint against the logical forms of the second case, in which the quantifier over event-indexed sets has scope over the quantifier over individual objects, then the interpretation in (60e) is not represented, although no unacceptable interpretations are assigned. We will see that event logic succeeds in representing the interpretation in (60e) while avoiding the unacceptable interpretations. And we will see that the crucial difference between event logic and set-denotative logic concerns the well-formedness of formulas " Φ " in (318), (319) and (320) that contain " \forall " but not the variable " x ".

6.1.1 Excursus.

Jim Higginbotham points out (p.c.) that syntactic differences between event logic and set-denotative logic also have a semantic effect which is not concerned with quantifying over events. It concerns the relation between sets and individual objects.

(337) Most of the boys danced with most of the girls.

(338) * [EY:most girls(Y)][Most x:boy(x)] boy(x) danced with girls(Y)

(339) * [EX:most boys(X)][Most y:girl(y)] boys(X) danced with girl(y)

Commenting on McCawley's (1970) remark that (337) has only three interpretations (two assignments of scope to quantifiers over individuals and the sum of plurals), Higginbotham notes that (337) lacks in particular the interpretations represented by (338) and (339). The first requires that there is a set containing most of the girls such that most of the boys each danced with them. Although it is possible through a standard assignment of scope to distribute "most of the boys", describing what each did, there is no interpretation of (337) that combines this assignment of scope with the requirement that they each danced with the same girls. We are then to compare systems of quantification on this point: to what extent any two quantifiers, $[QN'_1]$ and $[Q'N'_2]$, in a sentence can be interpreted so that $[QN'_1]$ -many individual objects are each required to be related to the same set of $[Q'N'_2]$.

In a system with n-ary quantification or, for example, the branching quantification of Barwise (1978), quantifiers of both types-- increasing and non-increasing-- can be so interpreted. Thus, the interpretations represented by (340b) and (341b), equivalent to (340c) and (341c) respectively, both require that the boys each danced with the same set of two girls.

(340)(non-increasing) a. Exactly two boys danced with exactly two girls.

b. $[2!x:\text{boy}(x)] \setminus$
 $[2!y:\text{girl}(y)] /$ boy(x) danced with girl(y)

c. $[EX:2! \text{ boys}(X)][EY:2! \text{ girls}(Y)] (x)(y)$
 $(x \in X \ \& \ y \in Y) \rightarrow \text{boy}(x) \text{ danced with girl}(y)$
 $\& \quad \text{boy}(x) \text{ danced with girl}(y) \rightarrow (x \in X \ \& \ y \in Y)$

(341)(increasing) a. Two boys danced with two girls.

b. $[2x:\text{boy}(x)] \setminus$
 $[2y:\text{girl}(y)] /$ boy(x) danced with girl(y)

c. $[EX:2 \text{ boys}(X)][EY:2 \text{ girls}(Y)] (x)(y) (x \in X \ \& \ y \in Y) \rightarrow \text{boy}(x) \text{ danced with girl}(y)$

In the new logic, which does not have n-ary or branching quantifiers, one can derive an interpretation that requires $[QN'_1]$ -many boys to each dance with the same set of $[Q'N'_2]$ -many girls only if $[Q'N'_2]$ is an increasing quantifier interpreted according to (304a) to have undivided reference to a denotatum. Thus the new logic will not make the mistake of assigning the unacceptable interpretation in (340): (342), interpreting "exactly two girls" as a non-increasing quantifier according to (305b), says that two and no more than two girls are among sets that were each danced with by exactly two

boys. It does not require that the same set of exactly two girls danced with each of two boys.

(342) [2! girls(<Y,j>)] [2!x:boy(x)] boy(x) danced with girls(<Y,j>)

(343) [Most girls(<Y,j>)] [Most x:boy(x)] boy(x) danced with girls(<Y,j>)

Similarly, the new logic will not assign (337) the interpretation represented in (338) unless the quantifier "[most girls(<Y,j>)]" in (343) is interpreted according to (304a) as an increasing quantifier. But, "most" need not be treated as an increasing quantifier: some set of most girls are dancers if and only if the set of all girls that are dancers are most girls. A version of the new logic that classifies "most" as only non-increasing, without loss to its meaning, will not assign (337) the unacceptable interpretation in (338).

We can be sure only of the new logic's (344), for sentences like (341) in which "two girls" may clearly be increasing, that it requires two boys to have each danced with the same set of two girls.

(344) [2 girls(<Y,j>)] [2x:boy(x)] boy(x) danced with girls(<Y,j>)

The event logic does not derive (at least not immediately, see below) any of the interpretations requiring the boys to have each danced with the same set of girls. But, as we have just seen, it disagrees clearly with the new logic (or any set-denotative logic without n-ary quantifiers) just in case an increasing quantifier is involved. Assuming one of the plurals to be a (complex) quantifier over individuals as in (345), the remaining plural if it is exported will also bind an individual variable, deriving the interpretation, represented by (346), that (exactly) two girls were each danced with by (exactly) two boys. It does not require the boys to be the same for all the girls.

(345) [2(!)<x,e>:boy(x)] INFL(e,x) danced with (exactly) two girls

(346) [Most<y,e>:girl(y)] [[Most<x,e>:boy(x)] INFL(e,x) [danced(e) with(e,y)]]

If the remaining plural in (345) stays in place as part of a predicate on events, the derived interpretation represented by (347) is that (exactly) two boys each danced with (exactly) two girls:

(347) [2(!)<x,e>:boy(x)] INFL(e,x) [danced(e) with(e, (exactly) two girls)]

Since, "(exactly) two girls" is within the scope of "(exactly) two boys", it is not required that all the boys dance with the same girls. The scope interactions in (344) or in (338) and (339) are not possible within event logic simply because an exported quantifier never binds a set-variable.

For the sentence (341) on which event logic and the new logic disagree clearly, the interpretation requiring the two boys to have each danced with the same girls seems to me less unacceptable than the other cases with non-increasing quantifiers. When "a certain" and "particular" are added as in (348) to favor the referential interpretation of the indefinite, that

interpretation is still more accessible although somewhat difficult.

- (348) a. Two particular boys (each) danced with two particular girls
 b. Two boys (each) danced with a certain two girls

Let us suppose that indeed there is an acceptable interpretation of (348) that requires two boys to have each danced with the same two girls. The event logic would have to assume, following Fodor and Sag(1982), that "two particular girls" in the representation for (348a) in (349) can be referential like a proper name or demonstrative. The interpretation represented would be the same as the one of (350) represented by (351).

(349) [2<x,e>:boy(x)] [INFL(e,x) [dance(e) with(e, two particular girls)]]

(350) Two boys (each) danced with them, two girls

(351) [2<x,e>:boy(x)] [INFL(e,x) [dance(e) with(e, them)]]

Fodor and Sag observe that in (69) and (70) "a student..." has a de dicto and a wide-scope de re interpretation; but it lacks the de re interpretation where it occurs within the scope of "each teacher".

(69) Each teacher overheard the rumor that a student of mine had been called before the dean.

(70) Each teacher thinks that for a student I know to be called before the dean would be preposterous.

(71) (a) (each teacher: x) [x overheard the rumor that [(a student of mine: y) [y had been called before the dean]]]

 (b) * (each teacher: x)[(a student of mine: y) [x overheard the rumor that [y had been called before the dean]]]

 (c) (a student of mine: y)[(each teacher: x) [x overheard the rumor that [y had been called before the dean]]]

Noting that complex NPs and sentential subjects are in general opaque domains for quantifier raising, they argue that "this missing-reading observation is a clear indication that the 'island-escaping' interpretation of an indefinite [(71a)] is not in fact an instance of a quantifier that manages to escape the island, but is an instance of something very like a proper name or demonstrative". The assumption that indefinites can be referential eliminates the apparent exception to opacity in (71a) and explains the missing interpretation.

Farkas (1981) rejects the argument for referential indefinites, citing the examples below in (17) where Fodor and Sag's missing interpretation appears to be acceptable. That is, (17a) has an interpretation where "some law..." is not within the scope of "three arguments..." but remains within the scope of "each student". (17b) has a similar interpretation. Farkas represents these interpretations by ordering the quantifiers as in (18).

- (17) a. Each student has to come up with three arguments which show that some law is wrong.
- b. Everybody told several stories that involved some member of the Royal family.
- (18) a. each some three
 b. each some several

Farkas shows that complex NPs do not in general exclude that interpretation where the embedded indefinite is not within the scope of the complex NP but is within the scope of the subject. One might add that the missing interpretation of Fodor and Sag's example (69) is found when the complex NP is itself dependent on the subject (cf. Fiengo and Higginbotham's (1981) specificity condition). Thus, (69') has the narrow scope de re interpretation in (71'c):

(69') Each student_i overheard (his_i rumor/ the rumor of his_i) that a student had been called before the dean.

(71'c) (each teacher: x)[(a student: y)[x overheard x's rumor that y had been called before the dean]]

Nevertheless, I believe that the line of Fodor and Sag's argument is shown to be correct when further examples are considered. Note that the indefinites in (17a), "three arguments" and "some law(sg.)", and those in (17b), "several stories" and "some member(sg.)" are such that their ordering in (18) with respect to each other is equivalent to their sum, that is where neither indefinite is within the scope of the other. Consider instead (17') where there is no equivalence between the sum of plurals interpretation of the indefinites and either of their scope interpretations.

(17') Each student has to come up with three arguments which show that three laws are wrong.

As in (17), there is an interpretation of (17') in which "three laws" is within the scope of "each student" and not within the scope of "three arguments"; but, in this interpretation neither is "three arguments" within the scope of "three laws". It is equivalent to (i), where Y and Z are variables over sets and x, a variable over individuals:

(i) [each x:student(x)][EZ:3 laws(Z)][EY:3 arguments(Y) show that Z are wrong] x has to come up with Y.

Each student has to come up with some three arguments, and they are to show that some three laws are wrong. In addition to (i), there is an interpretation of (17') where "three laws" is also not within the scope of "each student". According to this interpretation, equivalent to (ii), there are three particular laws and each student has to come up with three arguments that show they are wrong.

(ii) [EZ:3 laws(Z)][each x:student(x)][EY:3 arguments(Y) show that Z are wrong] x has to come up with Y.

Note that the student is not said to come up with three arguments for each of the laws.

Besides the above two interpretations, there are no others for (17') in which "three laws" is not within the scope of "three arguments". Thus, corresponding to (18), (iii) is unacceptable. It has "three laws" as a quantifier over individuals including within its scope "three arguments":

(iii) * [each x:student(x)][3z:law(z)][3y:argument(y) which shows that z is wrong]
x has to come up with y.

This interpretation would say that each student is to have three laws for each of which he has to come up with three arguments showing it is wrong. The complex NP is not transparent to the quantifier raising in (iii). Another example showing the same opacity is (17''):

(17'') Some student has to come up with some arguments which shows that three laws are wrong

(iv) * [3z:law(z)][Ex:student(x)][Ey:argument(y) shows that z is wrong]
x has to come up with y.

* [3z:law(z)][Ex:student(x)][EY:arguments(Y) show that z is wrong]
x has to come up with Y.

(v) [Ex:student(x)][E2:3 laws(Z)][EY:arguments(Y) show that Z is wrong]
x has to come up with Y.

(vi) Some student has to come up with some arguments which each show that three laws are wrong.

[Ex:student(x)][3y: [E2:3 laws(Z)] argument(y) shows that Z are wrong]
x has to come up with y

No interpretation of (17'') says, as in (iv), that for each of three laws, there is some student who has to come up with three arguments which show that it is wrong. There is a specific interpretation for "three laws", distinct from its interpretation in (vi) within the scope of "some arguments"; but, it is an interpretation equivalent to (v), which requires there to be some student, three laws, and some arguments which show that they are wrong.

The data in (i)-(vi) reconstitute Fodor and Sag's paradigm. The argument for referential indefinites is the same. The complex NPs in (17') and (17'') are opaque domains for quantifier raising, accounting for the unacceptability of (iii) and (iv). The alternation between referential and non-referential "three laws" in (352) (cf. (349) and (351) accounts for the interpretations of (17') in (i) and (ii):

(352) [Each(x,e):student(x)] [INFL(e,x) [has to come(e) up with(e,
NP [3 argmnts_i:INFL(e, which_i) [show(e) that INFL(e, 3 laws) [are wrong(e)]]]]]]]

What remains a problem for Fodor and Sag's view, a problem for any view that fails to identify the specific reference of an indefinite with its having wide scope, is the loss of May's (1977) condition on unbound variables to explain its effect on (17'), for example. In (ii), the embedded indefinite receives a specific interpretation while the indefinite complex NP remains dependent on the subject "each student". The indefinites cannot reverse roles, so that the indefinite complex NP is specific while the embedded one remains dependent on the subject. As is clear in (vii), the variable Z is unbound, violating May's condition.

(vii) * [EY:3 arguments(Y) show that Z are wrong][each x:student(x)][EZ:3 laws(Z):
x has to come up with Y.

With the difficulty just noted, the data in (i)-(vi) is independent evidence for indefinites as referential expressions, which, as we have seen, event logic must assume if (349) is to represent the interpretation that two boys each danced with the same two girls. To the extent this interpretation is unacceptable, event logic would of course not be committed to this assumption. In the new logic, such interpretations are a direct consequence of its quantificational apparatus, the assignment of scope to quantifiers over sets. They are expected to be systematically acceptable for increasing quantifiers. To the extent that such an interpretation is marginal for sentences like (341), we have an argument, albeit weak, against the new logic. But, the points on which the new logic and event logic differ are in this case rather few.

6.2

The examples in this section are from event-dependent and non-event-dependent quantification. In the event logic's event-dependent interpretations, " $\Phi(e)$ " in (336) will appear as the restriction on a universal quantifier over events:

(353) $[Ae \forall(e): [Q' \langle y, e \rangle; N' \langle y \rangle] R(e, y)] \text{ INFL}(e, [Q N'])$

These interpretations say that any event in which $[Q' N']$ -many individuals are each \forall 'ed is such that its INFL-ers are $[Q N']$. We have assumed that a non-event-dependent quantification that included " $\Phi(e)$ " in (336) would have the form in (354):

(354) $[Q\langle x, e \rangle : N'(x)] [INFL(e, x) [V(e) [Q'\langle y, e \rangle : N'(y)] R(e, y)]]$

(64)c. (non-event-dependent quantification)

" $_{NP} [Q\langle x, e \rangle : N'(x)] (R(e, x); \Phi(e)) \langle * \rangle$ " is true in C iff Q N'-many (and only Q N'-many) individuals a are such that there is some event E in C and some individuals A among which is a and "R(A, E)" is true in C and " $\Phi(E) \ast$ " is true in C.

When (354) is interpreted according to (64c) from sec. 3.1., p. 43, the derived interpretation says that [Q N']-many individuals are INFL-ers in events in which [Q' N']-many individuals are each V'ed. It will be shown that these interpretations are to be treated by quantifying over individual events that $\Phi(e)$ rather than by the new logic's quantifying over event-indexed sets that $\Phi(\langle X, i \rangle)$. As remarked earlier, these interpretations are obtained in the new logic from a logical form which is the closure of (334) by a quantifier that is interpreted according to one of the clauses in (305) (p. 164):

(355) $[Q N'(\langle X, i \rangle)] [Q' N'(y)] V(\langle X, i \rangle, y)$

(305)a. (event-dependent) "[Q N'] $\Phi(x)$ " is true iff every event-indexed set $\langle c, i \rangle$ is such that if " $\Phi(\langle c, i \rangle)$ " is true c is [Q N']-many.

b. (non-event-dependent) "[Q N'] $\Phi(x)$ " is true iff the union of all sets c such that for some event i " $\Phi(\langle c, i \rangle)$ " is true is [Q N']-many.

According to the new logic, the event-dependent interpretation of (355) says that any set and any event in which [Q' N']-many individuals are each V'ed by that set is such that that set is [Q N']. The non-event-dependent interpretation of (355) that is obtained from (304b) says that the union of all the sets that have an event in which it Vs each of [Q' N']-many individuals is [Q N']. We will see that the quantification over sets and

events results in unacceptable interpretations. Thus, this section will show that the particular interpretations which have been called event-dependent and non-event-dependent quantification have the structure attributed to them in event logic. They really do quantify over individual events and not over (event-indexed) sets.

As in earlier sections, the argument concerns the interpretations of sentences (356) and (357) in particular contexts both of which are represented by (358).

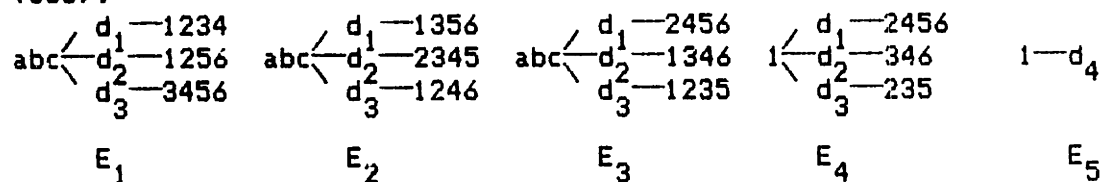
(356) No more than three senators (ever) spoke in favor of exactly three amendments

(357) No more than three billiard balls (ever) bounced off exactly three sides of the pool table.

(359) No more than three senators (ever) spoke in favor of exactly one amendment

(360) No more than three billiard balls (ever) bounced off exactly one side of the pool table.

(358):



The events in the context for (356) are five senatorial sessions at which senators are invited to speak in favor of pet amendments. Many senators have been speaking in favor of four distinct amendments, d_1 , d_2 , d_3 and d_4 . a , b and c are three distinct senators, and apart from these, there are six other senators, numbered 1 through 6. (358) contains nine distinct senators. The five blocks represent in some detail who spoke in favor of which of the three amendments at each session. Senators a , b and c spoke in favor of all three at each of the first three sessions. When they had the floor, they took care to recommend them all. In the first session, senators 1 through 4 also

spoke in favor of the first amendment, senators 1, 2, 5, and 6 in favor of the second amendments, and senators 3, 4, 5 and 6 in favor of the third amendment. What happened in the following sessions is similarly spelled out by the next four blocks in (358).

The sentence in (357) is about the behavior of billiard balls on a pool table in a sequence of breaks. A break is when fifteen balls in a close triangular formation are scattered by the sudden impact of a sixteenth ball. The events in the context for (357) are five breaks on a particular pool table. As a result of the sudden impact, many of the billiard balls bounce off three particular sides of the table. a, b and c are three distinct balls, and apart from these, there are six other balls, numbered 1 through 6. (358) contains nine distinct billiard balls.⁸¹ The five blocks represent what bounced off which of the four sides at each break. The balls a, b and c bounced off all three sides d_1 , d_2 and d_3 in each of the first three breaks. In the first break, balls 1 through 4 also bounced off the first side. What else happened in this and following breaks is similarly spelled out by the blocks in (358).

Now in this context, any acceptable interpretation of (356) or of (357) is false. In contrast to the falsity of these sentences, any acceptable interpretation of (359) or of (360) is true in the context of (358).

We first consider (356) and (357). Note that each of the first four sessions is an event of speaking in favor of exactly three amendments; but,

81. Seven of the sixteen balls in a break are unaccounted for. Assume they fall into pockets without bouncing off any sides.

they each involve more than three senators. The first three sessions each involve nine senators, and the fourth involves six. Similarly, each of the first four breaks is an event of bouncing off exactly three sides, each involving more than three billiard balls. Thus, the event-dependent interpretations (361) and (362) and the non-event-dependent interpretations (363) and (364) that add up the participants in all such events are false.

(361) [Ae: speak(e) in favor of 3! amendments] INFL(e, 3 senators)

(362) [Ae: bounce(e) off 3! sides] INFL(e, no more than 3 balls)

(363) [3 senators(x)][Ee: speak(e) in favor of 3! amendments] $x \in e$ ⁸²

(364) [no more than 3 balls(x)][Ee: bounce(e) off 3! sides] $x \in e$ ⁸³

Also false are those interpretations that require individual variables (v. (322) and (326):

(367)a. [3 sntrs(x)][3! amndmnts(y)]Ee sntr(x) spoke(e) in favor of amndmnts(y)

82. We use (363) to stand for the interpretation derived in event logic from (i) by interpreting the first quantifier according to (64c):

(i) [3(x,e):senator(x)] [INFL(e,x) [speak(e) in favor of(e, 3! amendments)]]

Interpretations derived from (64c) will in other examples be treated similarly.

83. In the logic of clauses (304) and (305), the interpretations corresponding to (361), (362), (363) and (364) are obtained from an atomic predicate between event-indexed sets. No individual variables are required. For both types of interpretations, the quantifiers are interpreted in the order shown in (365) and (366):

(365) [3 sntrs(<X,i>)][3! amndmnts(<Y,j>)] sntrs(<X,i>) spoke
in favor of amndmnts(<Y,j>)

(366) [3 balls(<X,i>)][3! sides(<Y,j>)] balls(<X,i>) bounce off sides(<Y,j>)

(361) and (362) are derived by interpreting the first quantifier according to (305a), and (363) and (364) by interpreting the first quantifier according to (305b) (v. (321) and (325)).

- b. [3 sntrs(x)]Ee[3! amndmnts(y)] sntr(x) spoke(e) in favor of amndmnts(y)⁸⁴
- (368)a. [3 balls(x)][3! sides(y)]Ee ball(x) bounce(e) off sides(y)
- b. [3 balls(x)]Ee[3! sides(y)] ball(x) bounce(e) off sides(y)
- (369)a. [3! amndmnts(y)][3 sntrs(x)]Ee sntrs(x) spoke(e) in favor of amndmnt(y)
- b. [3! amndmnts(y)]Ee[3 sntrs(x)] sntrs(x) spoke(e) in favor of amndmnt(y)
- (370)a. [3! sides(y)][3 balls(x)]Ee balls(x) bounced(e) off side(y)
- b. [3! sides(y)]Ee[3 balls(x)] balls(x) bounced(e) off side(y)

Note that every one of the nine senators except number 1 has in the course of these five sessions spoken in favor of exactly three amendments. Senator 1 has spoken in favor of four amendments. Those eight senators thus falsify the interpretation represented by (367a). The interpretation in (367b) is about what the individual senator has done within some event. Note that senators a, b and c have each spoken within a single session in favor of exactly three amendments, and so has Senator 1, in the fourth session. Thus, (367b) is falsified by these four senators.

Similarly, every billiard ball except number 1 has in the course of the five breaks bounced off exactly three sides. The eight balls that have done so falsify the interpretation in (368a). (368b) is also falsified. Balls a, b and c and Ball 1 have each within a single break bounced off three sides. These four balls thus falsify (368b).

84. We use (367a) and (367b) to stand for the interpretations derived respectively from (64a) and (64b) (p.43) when these clauses are applied to the first quantifier in (i):

(i) [3(x,e):senator(x)] [INFL(e,x) [speak(e) in favor of(e, 3! amendments)]]

Interpretations derived from (64a) and (64b) will in other examples be treated similarly.

The interpretations in (369) and (370) where the object quantifier has wide scope and binds an individual variable are also false. Even within a single session, only amendment d_4 ; in the last session, was spoken in favor of by no more than three senators. So, there are not three amendments that not more than three senators ever spoke in favor of. Similarly, there are not three sides that no more than three balls ever bounced off of.⁸⁵

In contrast to (356) and (357), the acceptable interpretations of (359) and

85. It seems that the analogue to (363) with inverted scope is unacceptable. [In this note, only the interpretations of (356) will be cited. Similar remarks hold of (357)]:

(371):

[3! amendments(y)][Ee: \exists 3 senators speak(e) in favor of amendments] $y \in e$

This interpretation concerns events of speaking by no more than three senators. It is in any case false in (358): none of the sessions is an event fitting the description, and therefore there are not three amendments in such events.

The analogue to (361) exchanging the positions of the NP quantifiers is also unacceptable:

(372):

[Ae: \exists 3 senators speak(e) in favor of amendments][3! amendments(y)] $y \in e$

According to (372), any event of speaking by no more than three senators involves exactly three amendments. This interpretation is in any case falsified in (358) by the last session, which involves no more than three senators and does not contain exactly three amendments.

The subject-object asymmetry evident in the contrasts between (363) and (371) and between (361) and (372) is taken up in Schein (in progress).

We should also note that other interpretations of (356), marginal or unacceptable on account of the decreasing subject quantifier, are also false in (358). Thus, the sum of plurals interpretation which requires that no more than three senators spoke in favor of amendments and exactly three amendments were spoken in favor of by senators is falsified by the nine senators speaking in favor of amendments. Since, these nine spoke in favor of amendments at each of the first three sessions, the interpretation with an unrestricted universal quantifier over events, requiring each event to satisfy the sum of plurals interpretation, is also false. See sec. 5.1.1.

(360) are true in the context of (358). Only the last block of (358) represents an event of speaking in favor of exactly one amendment or an event of bouncing off exactly one side. Since, the only relevant event involves just one senator or one billiard ball, the event-dependent and non-event-dependent interpretations of (359) and (360) are all true:

(373) [$\exists e$: speak(e) in favor of 1! amendments] INFL(e , $\exists 3$ senators)

(374) [$\exists e$: bounce(e) off 1! sides] INFL(e , $\exists 3$ balls)

(375) [$\exists 3$ senators(x)] [$\exists e$: speak(e) in favor of 1! amendments] $x \in e$

(376) [no more than 3 balls(x)] [$\exists e$: bounce(e) off 1! sides] $x \in e$

Also true are the interpretations that require individual variables:

(377)a. [$\exists 3$ sntrs(x)] [$\exists 1$! amndmnts(y)] $\exists e$ sntr(x) spoke(e) in favor of amndmnts(y)

b. [$\exists 3$ sntrs(x)] $\exists e$ [$\exists 1$! amndmnts(y)] sntr(x) spoke(e) in favor of amndmnts(y)

(378)a. [$\exists 3$ balls(x)] [$\exists 1$! sides(y)] $\exists e$ ball(x) bounce(e) off sides(y)

b. [$\exists 3$ balls(x)] $\exists e$ [$\exists 1$! sides(y)] ball(x) bounce(e) off sides(y)

(379)a. [$\exists 1$! amndmnts(y)] [$\exists 3$ sntrs(x)] $\exists e$ sntrs(x) spoke(e) in favor of amndmnt(y)

b. [$\exists 1$! amndmnts(y)] $\exists e$ [$\exists 3$ sntrs(x)] sntrs(x) spoke(e) in favor of amndmnt(y)

(380)a. [$\exists 1$! sides(y)] [$\exists 3$ balls(x)] $\exists e$ balls(x) bounced(e) off side(y)

b. [$\exists 1$! sides(y)] $\exists e$ [$\exists 3$ balls(x)] balls(x) bounced(e) off side(y)

Within each event except the last, every senator is related to two or three of the amendments. Since, only Senator 1 has spoken within a single session, the last, in favor of exactly one amendment, the interpretation in (377b) is true. Across the span of five, sessions every senator has in fact spoken in favor of three or four amendments. Thus, (377a) is true. Similarly, the interpretations of (378) are true for the billiard balls and the sides of the pool table in the context of (358).

The interpretations in (379) and (380) where the object quantifier has wide scope are also true. There is exactly one amendment, d_4 , spoken in favor of by no more than three senators within a single event or throughout. Similarly, side d_4 is the only one to be bounced off within a single break by no more than three balls, and only one ball has bounced off it throughout all five breaks.

We now show that the new logic (or the alternative in n. 71) assigns interpretations to (356) and to (357) that are true in (358) although their acceptable interpretations are all false in (358)⁸⁶. In contrast, the event logic will, correctly, not assign such true interpretations.

The true interpretations in the new logic are the two conforming to each of (381) and (382):

(381) [≤ 3 sntrs($\langle X, i \rangle$)] [3! amndmnts(y)] sntrs($\langle X, i \rangle$) spoke in favor of amndmnt(y)

(382) [≤ 3 balls($\langle X, i \rangle$)] [3! sides(y)] balls($\langle X, i \rangle$) bounced off side(y)

One of their interpretations is obtained by interpreting the outermost quantifiers "[No more than three senators($\langle X, i \rangle$)]" and "[No more than three balls($\langle X, i \rangle$)]" as event-dependent according to (305a), and the other of their interpretations is obtained by interpreting the quantifiers as non-event-dependent according to (305b). Note that the outermost quantifiers in (381) and (382) close formulas expressing properties of event-indexed sets of the form in (334). The atomic predicates in (381) and (382) both express a relation between event-indexed sets and individual objects.

86. The marginal or unacceptable interpretations in n. 85 are also false in (358).

The two interpretations of (381) are about the number of senators belonging to event-indexed sets that speak in favor of exactly three amendments, and the two interpretations of (382) are about the number of balls belonging to event-indexed sets that bounce off exactly three sides. The contexts represented by (358) contain no event-indexed sets that meet these descriptions when they are specified as in (381) and (382) with an individual variable γ . These interpretations are then vacuously true in (358). Consider what is obtained from (305a) and (305b) when applied to the first quantifiers in (381) and (382):

(383)(event-dependent) (381) is true iff every event-indexed set $\langle C, i \rangle$ is such that if "senators $\langle C, i \rangle$ spoke in favor of exactly three amendments" is true, c is no more than three senators.

(384)(event-dependent) (382) is true iff every event-indexed set $\langle C, i \rangle$ is such that if "balls $\langle C, i \rangle$ bounced off exactly three sides" is true, c is no more than three balls.

(385)(non-event-dependent) (381) is true iff the union of a sets c such that for some event i "senators $\langle \langle C, i \rangle \rangle$ spoke in favor of exactly three amendments" is true is no more than three senators.

(386)(non-event-dependent) (382) is true iff the union of a sets c such that for some event i "balls $\langle \langle C, i \rangle \rangle$ bounced off exactly three sides" is true is no more than three balls.

For either interpretation conforming to (381), an event-indexed set $\langle C, i \rangle$ is relevant just in case (387) is true, and an event-indexed set is relevant for either interpretation conforming to (382) just in case (388) is true:

(387) [3! amendments $\langle \gamma \rangle$] senators $\langle \langle C, i \rangle \rangle$ spoke in favor of amendment $\langle \gamma \rangle$

(388) [3! sides $\langle \gamma \rangle$] balls $\langle \langle C, i \rangle \rangle$ bounced off side $\langle \gamma \rangle$

But, for the given contexts, these can be true and an event-indexed set $\langle C, i \rangle$ relevant only if there are three distinct d_j , d_k and d_l such that:

(389) senators $\langle \langle C, i \rangle \rangle$ spoke in favor of amendment $\langle d_j \rangle$ &
 senators $\langle \langle C, i \rangle \rangle$ spoke in favor of amendment $\langle d_k \rangle$ &
 senators $\langle \langle C, i \rangle \rangle$ spoke in favor of amendment $\langle d_l \rangle$

(390) balls($\langle C, i \rangle$) bounced off side(d_j) &
 balls($\langle C, i \rangle$) bounced off side(d_k^j) &
 balls($\langle C, i \rangle$) bounced off side(d_l^k)

The atomic sentences that are the conjuncts of (389) and (390), are true according to (391) and (392), which are instances of the schema for denoting individuals exemplified in (323) and (327):

(391) c. "senators($\langle C, i \rangle$) speak in favor of amendment(d)" is true iff
 i. (relational structure) C are senators, d is an amendment, and
 C speak in favor of d , and
 (event structure) ii. C speak in favor of d at i , and
 iii. for all sets X of senators, Y of amendments,
 if X speak in favor of Y at i , then $X \subseteq C$.

(392) c. "billiard balls($\langle C, i \rangle$) bounce off side(d)" is true iff
 i. (relational structure) C are billiard balls d is a side (of the pool table),
 and C bounce off d , and
 (event structure) ii. C bounce off d at i , and
 iii. for all sets X of billiard balls, Y of sides,
 if X bounce off Y at i , then $X \subseteq C$.

Observe now that no event-indexed sets in the contexts represented by (358) meet either (389) or (390). According to sec. 5.1, and reflected in clause iii. of (391) and (392), an (event-indexed) set denoted by the predicate must exhaust the participants (in the same role) of its event. The same set satisfies this condition in each of the first three events depicted in (358), viz., $C_{1-3} = \{a, b, c, 1, 2, 3, 4, 5, 6\}$. In the fourth event, the set satisfying the condition is $C_4 = \{1, 2, 3, 4, 5, 6\}$, and in the last event, it is $C_5 = \{1\}$. Thus, for the events in (358), only $\langle C_{1-3}, E_1 \rangle$, $\langle C_{1-3}, E_2 \rangle$, $\langle C_{1-3}, E_3 \rangle$, $\langle C_4, E_4 \rangle$ and $\langle C_5, E_5 \rangle$ are denotable by the predicates in (391) and (392). But, none of these event-indexed sets, except for $\langle C_5, E_5 \rangle$, satisfy (393) or (394) with any of the individuals d_j (d_1, d_2, d_3 or d_4):

(393) senators($\langle C_k, E_i \rangle$) speak in favor of amendment(d_j)

(394) balls($\langle C_k, E_i \rangle$) bounce off side(d_j)

In the first session, the senators $\langle C_{1-3} \rangle$ have not all spoken in favor of the first amendment, nor all in favor of the second amendment, nor all in favor of the third. Similarly, in the first break, the balls $\langle C_{1-3} \rangle$ have not all bounced off the first side nor off any of the other two sides. The first four sessions and breaks are identical in this respect. Thus, none of the first four event-indexed sets in the contexts represented by (358) meet (389) or (390).⁸⁷ As for the last event-indexed set $\langle C_5, E_5 \rangle$, it and only one

87. The point is not to deny that a group of senators can be considered to have spoken in favor of an amendment if the spokesman among them has. Of course, bouncing billiard balls provide more convenient examples since one cannot readily attribute to them collective action. In any case, let us assume that the predicate "senators(x) speak in favor of amendments(y)" has an interpretation concerning their collective action rather than their individual, physical speeches. Although all the senators are not required to speak, I assume it is not in general true that if some senator has spoken in favor of an amendment, then any arbitrary set of senators containing him has spoken in favor that amendment. Although that senator's speaking may count for the group of senators C, there may be supersets of C for which it does not count. We now reinterpret the context that (358) represents. The blocks stand for a sequence of senatorial sessions, at which spokesmen declare their group's commitment to various amendments. Sentence (356) is in this context about how many senators end up committed in one way or another to how many amendments. Let each line in (358) connecting a set and an amendment mean that that set of senator's spokesman has spoken for that amendment for that session. If a particular set and a particular amendment are not connected by a line, then that set of senators has not acted collectively to speak in favor of that amendment. Such a context can be constructed because we do not consider any arbitrary set that contains a speaker to be spoken for. For collective action, a set must be more cohesive in some way, and that way is in this context absent whenever there is no connecting line. The first four sessions in (358) continue to be events of senators speaking in favor of exactly three amendments (now via their different spokesmen). The argument in terms of this predicate of collective action is developed in a way that parallels the argument in the text. The new logic stills assigns an unacceptable interpretation to (356) that is true in (358), since no event-indexed set meets the condition in (389). In particular, the only event-indexed sets from the first four sessions which are denotable according to sec. 5.1. are $\langle C_{1-3}, E_1 \rangle$, $\langle C_{1-3}, E_2 \rangle$, $\langle C_{1-3}, E_3 \rangle$ and $\langle C_4, E_4 \rangle$. None of these meet (389). No spokesman for any of these sets of senators spoke in favor of any of the three amendments. In first session, for example, there is no individual amendment to which the members of C_{0-3} were collectively committed.

if X bounce off* $\langle d \rangle$ at i , then XCC .

(397) c. "senators($\langle C, i \rangle$) speak in favor of amendment(d)" is true iff
i. (relational structure) C are senators, d is an amendment, and
 C speak in favor of* $\langle d \rangle$, and
(event structure) ii. C speak in favor of* $\langle d \rangle$ at i .

(398) c. "billiard balls($\langle C, i \rangle$) bounce off side(d)" is true iff
i. (relational structure) C are billiard balls d is a side (of the pool table),
and C bounce off* $\langle d \rangle$, and
(event structure) ii. C bounce off* $\langle d \rangle$ at i .

Relativizing the restriction to values of the individual variables creates more denotable event-indexed sets. In the first event in (358), the maximal set related to d_1 is $\langle a, b, c, 1, 2, 3, 4 \rangle$; and so, (393) and (394) are true of $\langle \langle a, b, c, 1, 2, 3, 4 \rangle, E_1 \rangle$ and d_1 . They are similarly true of $\langle \langle a, b, c, 1, 2, 5, 6 \rangle, E_1 \rangle$ and d_2 , and of $\langle \langle a, b, c, 3, 4, 5, 6 \rangle, E_1 \rangle$ and d_3 . These three event-indexed sets are the only ones from the first event made denotable by the relativized restriction in (395) and (396). Although they are each related to one individual d_i , none satisfies (389) or (390) by being related to three individuals. Note that the senators of $\langle a, b, c, 1, 2, 3, 4 \rangle$ have not all spoken in favor of the second or third amendments in the first session. Similarly, the balls in $\langle a, b, c, 1, 2, 3, 4 \rangle$ have not all bounced off the second or third sides of the pool table in the first break. The situation in the other events is the same. None of the new event-indexed sets that can be denoted under the relativized restriction in (395) and (396) meet (389) or (390). Since, there are no new ones, all such sets still contain individually or jointly no more than three members, and therefore all the interpretations conforming to (381) and (382) remain true. The new logic will still incorrectly attribute to the sentences (356) and (357) interpretations true in (358).

Suppose instead that the restriction from sec. 5.1 is abandoned altogether

in the case of a predicate with individual variables, as in (397) and (398). Any event-indexed set can be denoted. Then, in (358), the event-indexed sets $\langle \{a,b,c\}, E_1 \rangle$, $\langle \{a,b,c\}, E_2 \rangle$, $\langle \{a,b,c\}, E_3 \rangle$ and $\langle \{1\}, E_4 \rangle$ each meet (389) and (390). They are each related to three and only three individuals d_i . These sets taken together contain four members, and thus the non-event-dependent interpretations of (381) and (282) are falsified (see (385) and (386)). Their event-dependent interpretations (see (383) and (384)) however remain true in (358), since each of the event-indexed sets related to exactly three individuals does contain no more than three members: a, b and c, or just 1. Even abandoning the restriction from sec. 5.1 for predicates with individuals variables, interpretations assigned to sentences (356) and (357) come out true.

In attempting to eliminate from the new logic interpretations of (356) and (357) that are incorrectly true in (358), we have considered ways to weaken the restriction from sec. 5.1. Recall now that, in contrast to (356) and (357), the acceptable interpretations of (359) and (360) are true in (358). The interpretation of these sentences provide a general objection to any scheme that will weaken the restriction from sec. 5.1⁸⁸. Although such a scheme might succeed in making all interpretations of (356) and (357) false in (358), it will also make interpretations of (359) and (360) false in (358). The affected interpretations in the new logic are the two conforming to each of (399) and (400) and shown in (401)–(404):

(399) [\exists sntrs($\langle X, i \rangle$)] [1! amndmnts(y)] sntrs($\langle X, i \rangle$) spoke in favor of amndmnt(y)

88. It also provides a counterexample to weakening the restriction from sec. 5.2 against cross-event properties of sets. See note below.

(400) [≤ 3 balls $\langle X, i \rangle$][$1!$ sides $\langle y \rangle$] balls $\langle X, i \rangle$ bounced off side $\langle y \rangle$

(401)(event-dependent) (381) is true iff every event-indexed set $\langle C, i \rangle$ is such that if "senators $\langle C, i \rangle$ spoke in favor of exactly one amendments" is true, c is no more than three senators.

(402)(event-dependent) (382) is true iff every event-indexed set $\langle C, i \rangle$ is such that if "balls $\langle C, i \rangle$ bounced off exactly one sides" is true, c is no more than three balls.

(403)(non-event-dependent) (381) is true iff the union of a sets c such that for some event i "senators $\langle C, i \rangle$ spoke in favor of exactly one amendments" is true is no more than three senators.

(404)(non-event-dependent) (382) is true iff the union of a sets c such that for some event i "balls $\langle C, i \rangle$ bounced off exactly one sides" is true is no more than three balls.

Recall that the less drastic move in (395) and (396), relativizing the restriction from sec. 5.1. to values of the individual variable, made a number of new event-indexed sets denotable. As was pointed out, these are each related in (358) to one, in fact exactly one, individual d_i . Thus, $\langle \{a, b, c, 1, 2, 3, 4\}, E_1 \rangle$ satisfies (393) and (394) with d_1 and with no other. The other event-indexed sets made denotable by the weakened restriction are also each related to exactly one d_i : $\langle \{a, b, c, 2, 3, 4, 5\}, E_2 \rangle$ to only d_2 , $\langle \{a, b, c, 1, 2, 3, 5\}, E_3 \rangle$ to only d_3 , $\langle \{1, 3, 4, 6\}, E_4 \rangle$ to only d_2 , etc. Now each of these sets separately and therefore together as well contain more than three members. They thus falsify all the interpretations conforming to (399) and (400). The new logic will then incorrectly attribute to sentences (359) and (360) interpretations false in (358). Other schemes to weaken the restriction, such as abandoning it altogether as in (397) and (398), will have the same effect, resulting in false interpretations if they make denotable at least the above event-indexed sets. The weaker schemes will also admit other event-indexed sets related to exactly one individual d_i . From the first event, $\langle \{1, 2, 3, 4\}, E_1 \rangle$, $\langle \{1, 2, 5, 6\}, E_1 \rangle$ and $\langle \{3, 4, 5, 6\}, E_1 \rangle$ are

event-indexed sets, among others, related to exactly one d_i . Since, they each contain more than three members, they would each suffice to falsify all the interpretations of (399) and (400).⁸⁹

We have so far shown that the new logic when individual variables are introduced according to (391) and (392) misinterprets sentences (356) and (357), assigning them interpretations that are incorrectly true in (358). Particular alternatives to (391) and (392) that relax the restriction of sec. 5.1 also misinterpret (391) and (392). We have also suggested that any such alternative will result in the misinterpretation of (359) and (360), assigning them interpretations that are incorrectly false in (358). In short, the misinterpretation of sentences such as (356) and (357) is a robust feature of the new logic (or any set-denotative logic with events). The unacceptable interpretations result from the assignment of logical forms, (381) and (382), which are closures of formulas of the form in (334).

Event logic will not assign to (356) and (357) interpretations that are true in (358). Such interpretations were derived in the new logic from predicates that express relations between (event-indexed) sets and individuals, "senators($\langle x, i \rangle$) speak in favor of amendment(y)" and "billiard balls($\langle x, i \rangle$) bounce off side(y) of the pool table". The (event-indexed) sets are not available to event logic. We will however compare the event logic's treatment of the event-dependent and non-event-dependent interpretations of (356) and (357).

89. Note that all of the sets mentioned, $\{a, b, c, 1, 2, 3, 4\}$ and the others, retain the property of being related to exactly one d_i even if we consider what they did throughout (358) across all of the events, suspending the restriction of sec. 5.2.

(356) No more than 3 senators (ever) spoke in favor of exactly 3 amendments.

(381) [3 sntrs($\langle X, i \rangle$)] [3! amndmnts(y)] sntrs($\langle X, i \rangle$) spoke in favor of amndmnt(y)

(357) No more than 3 billiard balls (ever) bounced off exactly 3 sides of the pool table.

(382) [3 balls($\langle X, i \rangle$)] [3! sides(y)] balls($\langle X, i \rangle$) bounced off side(y)

Recall that the first quantifier in (381) and (357) could be interpreted in either of two ways: according to (301a) to obtain an event-dependent interpretation, or according to (301b) to obtain a non-event-dependent quantifier over events. What results is the new logic's version of those interpretations of (356) and (357) paraphrased in (405) and (406):

(405) a. (event-dependent) Any event of senators speaking in favor of exactly three amendments involves no more than three senators

b. (non-event-dependent) No more than three senators are in events of senators speaking in favor of exactly three amendments

(406) a. (event-dependent) Any event of billiard balls bouncing off exactly exactly three sides of the pool table involves no more than three billiard balls

b. (non-event-dependent) No more than three billiard balls are in events of billiard balls bouncing of exactly exactly three sides of the pool table

These interpretations in the event logic are equivalent to (407) and (408):

(407)a:

[$\text{Ae: senators speak}(e)$ in favor of 3! amendments] INFL(e , {3 senators})

b:

[3 senators(x)] [$\text{Ee: senators speak}(e)$ in favor of 3! amendments] $x \in e$

(408) a:

[$\text{Ae: billiard balls bounce}(e)$ off 3! sides] INFL(e , {3 billiard balls})

b:

[3 billiard balls(x)] [$\text{Ee: bd. balls bounce}(e)$ off 3! side] $x \in e$

Recall now that the true interpretations in the new logic were the result of interpreting the second quantifier to be one that bound an individual

variable, as shown in (381) and (382). For in that case, one had to search (358) for event-indexed sets that satisfied (387) and (388):

(387) [exactly three amendments(y)] senators(<C,i>) spoke in favor of amendment(y)

(388) [exactly three sides(y)] balls(<C,i>) bounced off side(y)

These require a set C within an event i to be related to every one of exactly three individuals. We have seen that not enough of the event-indexed sets in (358) meet this requirement to falsify (381) or (382).

In the event logic, one looks at (358) for events that satisfy the restrictions on the event-quantifiers in (407) and (408):

(409) ...[Qe: senators speak(e) in favor of exactly three amendments]...

(410)...[Qe: billiard balls bounce(e) off exactly three sides of the pool table]..

In contrast to (387) and (388), these have no argument place for the value of an (event-indexed) set variable. This is the important property of event logic discussed in sec. 3.2. Thus, quantification over individuals in (411) and (412) will not require each of exactly three individuals to be related to the value of the set variable.

(411) ...[Qe: [3! amendments(y)] senators speak(e) in favor of amendment(y)]...

(412)...[Qe: [3! sides(y)] bd. balls bounce(e) off side (y) of pool table]...

It suffices that senators speak at e in favor of the individual amendment, and that billiard balls bounce at e off the individual side. Exactly as the paraphrases in (405) and (406) would have it, an event in (358) is relevant if exactly three amendments were spoken in favor of or exactly three sides of the pool table bounced off of. Since, every one of the first four events in (358) meets this description and their participants are separately and

jointly at least six, all the interpretations of (405) and (406) are false.

6.3

Recall from sec. 6.1, p. 181, that the new logic has only (333) to represent the interpretation of (31) and (330) that corresponds to (60e) in event logic. Recall also that the atomic predicates in the (333) have the truth conditions in (413) conforming to the schema illustrated by (323) and (327) above.

(31) Three agents sold twenty-five buildings to two investors.

(330) Three agents sold twenty-five buildings to two investors each.

(60)e. $\forall p [Ee \text{ sell}(e) : [25\langle y, e \rangle \text{ bldg}(y)] [0F\langle e, y \rangle \text{ to}(e, 2 \text{ invstrs})]] \text{ INFL}(e, 3 \text{ agnts})$

"Three agents together sold twenty-five buildings each to two investors"

(333) a. $[3 \text{ agnts}(\langle Z, i \rangle)] [25x: \text{bldg}(x)] [2y: \text{invstr}(y)] \text{ agnts}(\langle Z, i \rangle) \text{ sold bldg}(x)$
to invstr(y)

b. $[3 \text{ agnts}(\langle Z, i \rangle)] [25x: \text{bldg}(x)] [2 \text{ invstrs}(\langle Y, j \rangle)] \text{ agnts}(\langle Z, i \rangle) \text{ sold bldg}(x)$
to invstrs(\langle Y, j \rangle)

(413) a. "agents(\langle B, i \rangle) sell building(c) to investor(d)" is true iff
i. (relational structure) agents(B) sell* building(\langle c \rangle) to investor(\langle d \rangle), and
(event structure) ii. agents(B) sell* building(\langle c \rangle) to investor(\langle d \rangle) at i, and
iii. for all sets X, Y and Z,
if agents(X) sell* buildings(Y) to investors(Z) at i, then XCB.

b. "agents(\langle B, i \rangle) sell building(c) to investor(\langle D, j \rangle)" is true iff
i. (relational structure) agents(B) sell* building(\langle c \rangle) to investor(D), and
(event structure) ii. i=j, and agents(B) sell* building(\langle c \rangle) to investor(\langle d \rangle) at i,
and iii. for all sets X, Y and Z,
if agents(X) sell* buildings(Y) to investors(Z) at i, then XCB and ZCD.

A consequence of this section will be that (333) in fact fails to represent the interpretation paraphrased in (60e). We will show more generally that any logical form with the syntax imposed by set-denotative logic cannot

represent the class of interpretations similar to (60e). The set-denotative syntax requires that every plural NP binds either a variable over individual objects or a variable over sets in an atomic polyadic predicate. Thus, the logical form of a simple sentence with three plural NPs as in (414) conforms to (415).

(414) $S[NP_1 [V NP_2 [P NP_3]]]$

(416) $NP_1(\alpha_1), NP_2(\alpha_2), NP_3(\alpha_3) \quad S[\alpha_1 [V \alpha_2 [P \alpha_3]]]$

Since, our point is to show that a particular interpretation is not expressible within any logic assuming this syntax, we will be generous with the interpretation of quantifiers and allow the formation of n -ary quantifiers from NP_1 , NP_2 and NP_3 in (416).⁹⁰ Most of the argument of this work has been to demonstrate that the expressive power of set-denotative logic is too great, assigning many unacceptable interpretations. In order to show this, we found unacceptable interpretations that were assigned by set-denotative logics-- the new logic, the alternative in n. 71 and their antecedents-- that were as simple as possible. These unacceptable interpretations continue to be assigned when the simpler set-denotative logics are given the additional expressive power of something like n -ary quantifiers. But now that our point is to show an expressive weakness in set-denotative logic, we must consider all the ways that a logical form with the structure in (416) can be interpreted-- hence, the return of n -ary quantifiers.

As (416) shows, we are here indifferent to the place for events. What follows concerns any set-denotative logic with or without events. It focuses

90. See sec. 2.4.1 for the discussion of n -ary quantifiers.

on the relational structure, who did what to whom, that logical forms with the structure in (416) impose on any situation in which they are true. As this remark suggests, the one aspect of the truth conditions in (413) that will be crucial is labelled "relational structure". The truth conditions abbreviated by "V*" reflect the fact that the atomic predicates in set-denotative logic express true relations-- between sets, between individuals, and crucially between sets and individuals. That is, a dyadic predicate "V" is true of sets "they" and "them" just in case they V'ed them. Similarly, a dyadic predicate "V" is true of a set "they" and an individual "it" just in case they V'ed it:

- (417) a. "agents($\langle B, i \rangle$) sell building(c) to investor(d)" is true iff
 i. (relational structure) agents(B) sell building($\langle c \rangle$) to investor($\langle d \rangle$), and
 (event structure) ii. agents(B) sell building($\langle c \rangle$) to investor($\langle d \rangle$) at i , and
 iii. for all sets X, Y and Z ,
 if agents(X) sell buildings(Y) to investors(Z) at i , then XCB .
- b. "agents($\langle B, i \rangle$) sell building(c) to investor($\langle D, j \rangle$)" is true iff
 i. (relational structure) agents(B) sell building($\langle c \rangle$) to investor(D), and
 (event structure) ii. $i=j$, and agents(B) sell building($\langle c \rangle$) to investor($\langle d \rangle$) at i ,
 and iii. for all sets X, Y and Z ,
 if agents(X) sell buildings(Y) to investors(Z) at i , then XCB and ZCD .

In sec. 6.4, we consider set-denotative logics that give up the assumption that polyadic atomic predicates express true relations, and there the abbreviations "V*" stand for a Davidsonian decomposition of the predicate.

We now introduce in sec. 6.3.1 and 6.3.2 two important facts about the interpretations of which (60e) is an example.

6.3.1

We first observe that these interpretations of the sentences in (418)-(420) are true in the contexts depicted by (421) and described below. Appearing

with the sentences are the logical forms in event logic. The interpretations they represent are true in (421), as required.

(418) Three agents sold (the) two buildings to exactly two investors (each)
 [Ee sell(e): [(the)2(y,e):bldg(y)] OF(e,y) to(e, 2! invstrs)] INFL(e, 3 agents)

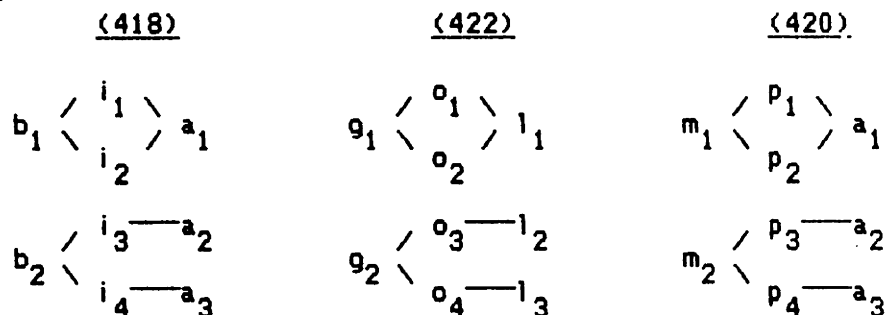
(422) Three letters of recommendation from influential figures earned the two new graduates exactly two offers.

[Ee earn(e):[the2(y,e):grad(y)] FOR(e,y) OF(e, 2! offers)] INFL(e, 3 letters)

(420) Three automatic tellers gave (the) two new members exactly two passwords (each)

[Ee give(e): [(the)2(y,e):nw mmbr(y)] TO(e,y) OF(e, 2! psswrds)] INFL(e, 3 atms)

(421)



For each of the sentences, it will be helpful to imagine circumstances that make the relative assignment of scope between the plural NPs in the VP especially meaningful. Suppose for (418) that the sale of a building to two or more investors creates the conditions under which a deed can be contested. The relevant interpretation of (418) then reports that (the) two buildings were conveyed with that risk and three agents were the involved sellers. For (422), suppose that a new graduate's situation is measured by his ability to play one job offer off against another. Naturally, success begins at two offers and improves with the chances for more elaborate plays as the number of offers increases. The relevant interpretation of (422) reports that three letters of recommendation were responsible for bringing

the two new graduates to the minimal level of success. For example (420), suppose that new members in any of several Christmas clubs at any of several banks are enrolled by assigning to each new member exactly two passwords of his own. The assignment of a password is made by computer and received at one of many automatic tellers. At one location, which (420) is about, there are many automatic tellers ejecting passwords from any of the different Christmas clubs. A new member enters the location, approaches one of the tellers, connects it to the Christmas club of his choice and requests one password. As a security precaution, to request another password he must repeat the process. The relevant interpretation of (420) reports that three automatic tellers were used when (the) two new members enrolled in Christmas clubs.

Each figure in (421) shows two distinct individuals in its leftmost column each related to exactly two distinct individuals. For (420), these are two new members, m_1 who is given passwords p_1 and p_2 and m_2 who is given passwords p_3 and p_4 . Similarly in the figure for (418), there are (the) two buildings, b_1 and b_2 , such that b_1 is sold to the two investors i_1 and i_2 , and b_2 is sold to the two investors i_3 and i_4 . For (422), (421) shows one new graduate g_1 winning job offers o_1 and o_2 , and the other graduate g_2 winning offers o_3 and o_4 .

Each of the figures in (421) also shows that three individuals bring about the state of affairs described above. (420)'s figure shows that new member m_1 was given the passwords to his Christmas club by one automatic teller a_1 ; but, new member m_2 was given one of his passwords by automatic teller a_2 , and the other password by another teller a_3 . The participation of the three

individuals is distributed in the same way in all of the figures. Thus, one of the agents, a_1 , is solely responsible for building b_1 being sold to exactly two investors, agent a_2 sells building b_2 to one investor, and agent a_3 sells it again to another investor. Similarly, one letter of recommendation l_1 earns the first graduate g_1 his two offers; but the second graduate g_2 wins his two offers each from a different recommendation.

The relevant interpretations of the sentences in (418)–(420) and their representation in event logic are true in the contexts of (421). (420)'s figure in (421) shows an event in which (the) two new members are each given exactly two passwords, and its givers are three automatic tellers. (421) depicts for (418) an event in which (the) two buildings are each sold to exactly two investors such that its sellers are three agents. Finally, (422)'s figure shows an event in which the two children are each earned exactly two offers, and its earners are three letters of recommendation.

The next observation is something that the argument requires us to keep track of: the sentences in (418)–(420) have another interpretation that is true in (421).

(425) Three agents sold (the) two buildings to exactly two investors (each)

$[3\langle x, e \rangle : \text{agnt}(x)] \text{ INFL}(e, x) [\text{sell}(e) [\langle \text{the} \rangle 2\langle y, e \rangle : \text{bldg}(y)] \text{ OF}(e, y) \text{ to}(e, 2! \text{ invstrs})]$

"Three agents are sellers in events of (the) two buildings each being sold to exactly two investors"

(426) Three letters of recommendation from influential figures earned the two new graduates exactly two offers

$[3\langle x, e \rangle : \text{lttr}(x)] \text{ INFL}(e, x) [\text{earn}(e) [\langle \text{the} \rangle 2\langle y, e \rangle : \text{grad}(y)] \text{ FOR}(e, y) \text{ OF}(e, 2! \text{ offers})]$

"Three letters of recommendation from influential figures are earners in events of the two new graduates each being earned exactly two offers"

(427) Three automatic tellers gave (the) two new members

exactly two passwords (each)

[3(x,e):atm(x)] INFL(e,x) [give(e) [(the)2(y,e):nw mmbr(y)] TO(e,y) OF(e,2! pswrds

"Three automatic tellers are givers in events of (the) two new members each
being given exactly two passwords"

Recall that their non-event-dependent interpretations in (425)–(427), derived from the above logical forms by (64c), allow the three individuals referred to by the subject to be distributed among possibly several events of the kind described by the VP. Despite this allowance, it happens to be a single event which all three participated in that makes the non-event-dependent interpretations true in (421).

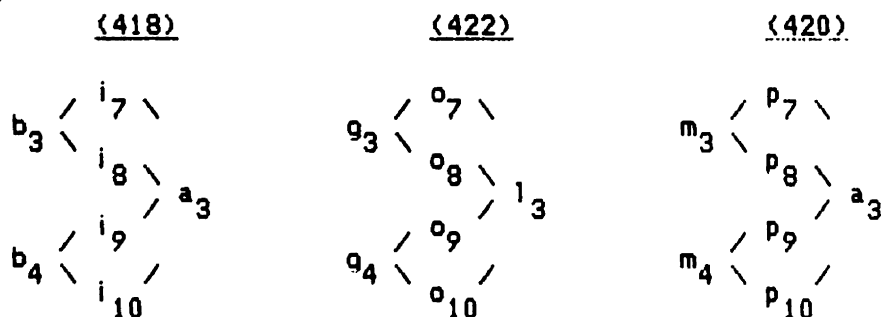
(428) ♦ [V(e) [(the)2(y,e):N'(y)] R(e,y) S(e, 2! N')]

That is, what happens in each figure in (421) can be no more than one event that has the property ♦(e) in (428), and because that event involves three individuals as INFL-ers, the non-event-dependent interpretation is true.⁹¹

Note that the interpretations in (418)–(420) and those in (425)–(427) are confirmed by the same things in each of the figures, viz., the one event that

91. The event-dependent interpretations of the sentences in (418)–(420) are also true in (421), unless we add to the contexts an event that falsifies the universal quantifier over events. Each figure in (429) shows an event in which (the) two individuals are each related to exactly two but its INFL-ers are just one.

(429)



$\Diamond(e)$. What is important for us is just this: (421)'s figures represent events that $\Diamond(e)$, and some of the sentences' interpretations are true in (421) only because there are such events. Although we develop the argument that set-denotative logic does not correctly represent the interpretations in (418)–(420) (cf. (60e)), an entirely parallel argument would show that set-denotative logic also fails to correctly represent non-event-dependent interpretations such as those in (425)–(427). The event-logical representations for both sets of interpretations require the existence of events that satisfy the formulas $\Diamond(e)$ in (428). Recall that these formulas are the kind that only event logic can use (cf. (320) on p. 172). As will be seen below, (421)'s figures have been designed so that, although they contain one event that $\Diamond(e)$, they contain none of the things, sets in particular, needed to satisfy (428)'s counterparts in set-denotative logic (cf. (318) and (319) on p. 172.). (430) is \Diamond 's counterpart in the new logic, and (431) is the counterpart in the alternative of n. 71.

(430) $[(\text{the})2y:N'(y)][2! N'(\langle Z,j \rangle)] \vee (\langle X,i \rangle, y, \langle Z,j \rangle)$

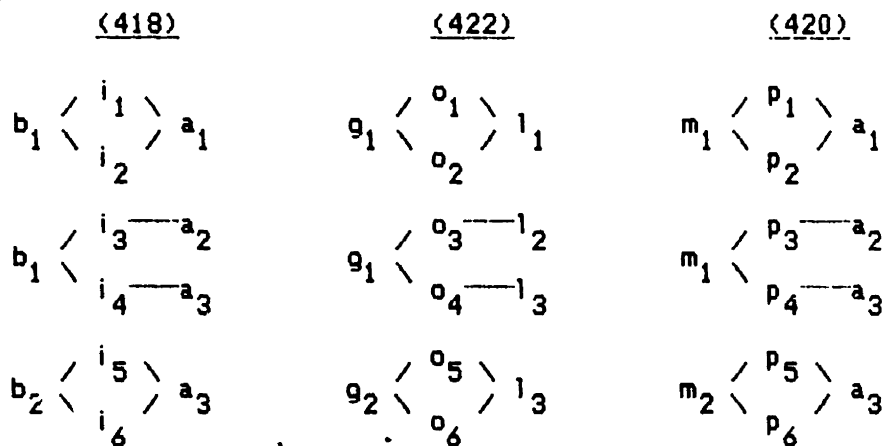
(431) $[(\text{the})2y:N'(y)][2! N'(Z)] \vee (X, e, y, Z)$

6.3.2

We now turn to the second important fact about the class of interpretations which (60e) is an example of. These interpretations for the sentences in (418)–(420) as well as the interpretations in (425)–(427) and other acceptable interpretations of these sentences are all false in the contexts

depicted in (432)⁹².

(432)



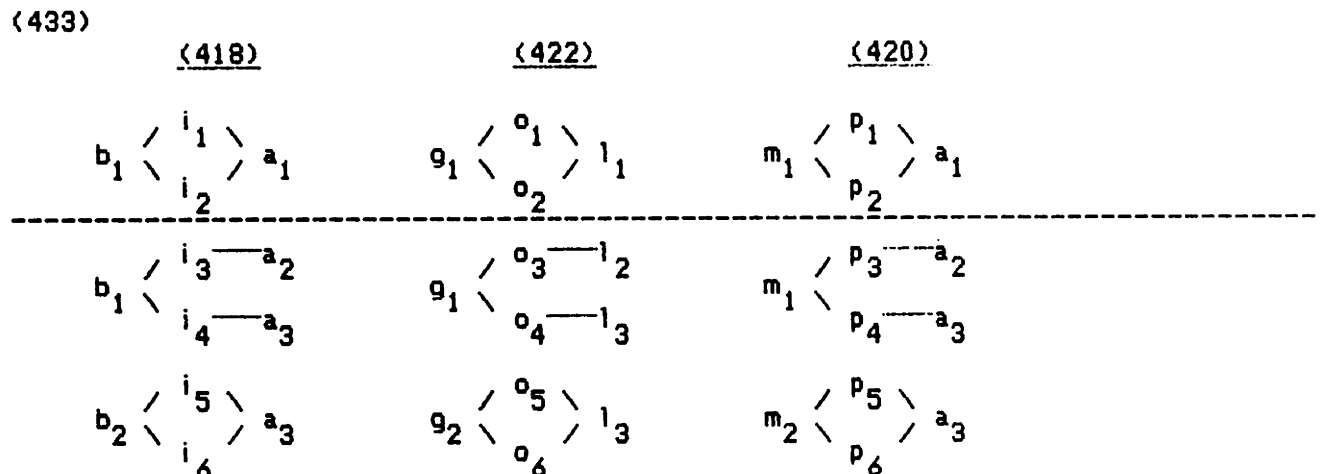
The figures in (432) are to be understood in the same way as those in (421). Note that none of them shows two individuals each being related to exactly two individuals. (420)'s figure shows two new members m_1 and m_2 , only one of which, m_2 is being given exactly two passwords. The new member m_1 is given four passwords. Similarly, (418)'s figure fails to show two buildings each being sold to exactly two investors. The figure contains only two buildings, one of which b_1 is sold to four investors. In (422)'s figure, one graduate g_1 earns four offers, and so there is only one graduate g_2 who is earned exactly two offers.

The interpretations in (418)-(420) and (425)-(427) and their representations in event logic are false in the contexts of (432). Assuming that what is shown for (420) is a single event, then there does not exist in

92. except the event-dependent interpretations which are vacuously true unless we add to the context a falsifying event, e.g., those in (429) in n. 91. All interpretations of the sentences in (418)-(420) are false in contexts which include the events depicted in (432) and the distinct events depicted in (429). In any case, it is easy not to confuse the event-dependent interpretations with the others.

that context an event in which (the) two new members are each given exactly two passwords, and so (420) and (427) are false. These interpretations of the other sentences are false for the same reason, when what is shown for each of them is a single event. There is no event in which (the) two individuals are each related to exactly two. In the single event shown, one of them is related to four.

Now observe that one cannot obtain contexts in which these sentences are true by regrouping what happened in (432) into contexts each with two events, as in (433) for example:



The regrouping creates only one event, the lower one, in which (the) two individuals are each being related to exactly two; but it is not brought about by three individuals. (420)'s figure in (433) contains two events, one of which is an event in which (the) two new members are each given exactly two passwords; but that event's givers are not three automatic tellers. They are only two tellers, a_2 and a_3 . Therefore, the interpretations in (420) and (427) remain false. The other sentences behave similarly in the contexts of (433).

We can thus say something somewhat stronger about these sentences. They are false in any domain of events derived from what happened in (432) or (433)^{93,94} It is obvious that the logical forms in (418)-(420) and in (425)-(427) represent interpretations false in (432) and (433), as required. Thus, the event logic's representations are correct with respect to the two facts observed, truth in (421) and falsity here in (432) and (433).

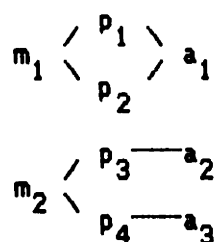
6.3.3

Having introduced these facts about interpretations such as the one paraphrased in (60e), let us now return to set-denotative logic to consider how it attempts to represent them. For convenience, we will develop just one of the examples for which we have constructed the situations in (421), (432) and (433):

(420) Three automatic tellers gave (the) two new members exactly two passwords (each)

[Ee give(e): [(the)2(y,e):nw mmbr(y)] TO(e,y) OF(e, 2! psswrds)] INFL(e, 3 atms)

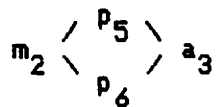
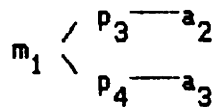
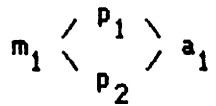
(421)



93. Chapter 3, especially sec. 3.4, points out that what happens in the world can be taken to correspond to different domains of events in different contexts.

94. Falsifying the event-dependent interpretations requires any of these contexts to include events like those in n. 91.

(432)



This interpretation of (420) requires that (the) two new members each be related to exactly two passwords. Thus, "(the) two new members" must bind a variable over individual objects and include within its scope "exactly two passwords". We allow "exactly two passwords" to bind either a variable over individual objects or a variable over sets. As for "three automatic tellers", the interpretation is about just three automatic tellers, and so "three automatic tellers" cannot be within the scope of "(the) two new members". We allow "three automatic tellers" to bind either a variable over individual objects or a variable over sets, and we will consider several ways in which its interpretation can interact with that of "(the) two new members", including the formation of a binary quantifier. In short, any possible logical form in set-denotative logic for the relevant interpretation must conform to (434).

(434) 3 atms(α_1); [(the)2(y):nw mmbr(y)]
2! psswrds(α_2) atms(α_1) gave nw mmbr(y) psswrds(α_2)

It is some kind of quantificational closure by "three automatic tellers" and "(the) two new members" of a formula free in a variable over individual objects, \underline{y} , bound by "(the) two new members", and a variable over sets or over individuals, $\underline{\alpha}_1$, bound by "three automatic tellers".

Recall also that the polyadic atomic predicates of set-denotative logic express true relations. (434) stands for logical forms that contain any one of four atomic predicates. These have among their truth conditions at least the following:

(435) "automatic teller(a) give new member(m) password(p)" is true iff
i. (relational str) automatic teller a gives new member m password p...

(436) "automatic teller(a) give new member(m) passwords(P)" is true iff
i. (relational str) automatic teller a gives new member m passwords P...

(437) "automatic tellers(A) give new member(m) password(p)" is true iff
i. (relational str) automatic tellers A give new member m password p...

(438) "automatic tellers(A) give new member(m) passwords(P)" is true iff
i. (relational str) automatic tellers A give new member m passwords P...

Note that the new logic's representations for this interpretation conform to (434) (Cf. (333)) and the truth conditions for its atomic predicates are instances of either (437) or (438) (Cf. (417)):

(439) a:

[3 atms(<X,i>)][(the)2y:nw mmbr(y)][2!z:psswrld(z)] atms(<X,i>) gave nw mmbr(y)
psswrld(z)

b:

[3 atms(<X,i>)][(the)2y:nw mmbr(y)][2! psswrds(<Z,j>)] atms(<X,i>) gave nw mmbr(y)
psswrds(<Z,j>)

(440) a. "automatic tellers(<A,i>) give new member(m) password(p)" is true iff
i. (relational str) automatic tellers A give new member m password p, and
(event str) ii. automatic tellers A give new member m password p at i, and
iii. for all sets X,Y and Z,
if automatic tellers X give new member Y password Z at i, then XCA.

b. "automatic tellers(<A,i>) give new member(m) password(<P,j>)" is true iff
i. (relational str) automatic tellers A give new member m password P, and
(event str) ii. i=j, & automatic tellers A give new member m password P at i,
and iii. for all sets X,Y and Z,
if automatic tellers X give new member Y password Z at i, then XCA and ZCP.

We will now see that the logical forms conforming to (434) fail to represent the intended interpretation of (420) and similar interpretations of

other sentences. The logical forms conforming to (434) are divided into two cases, discussed separately in sec. 6.3.3.1 and sec. 6.3.3.2. In the first case, those logical forms without a binary quantifier, including therefore all the forms in the new logic, are shown to represent interpretations that are false in the context that includes (421) and (429)⁹⁵. The second case includes the logical forms conforming to (434) in which "three automatic tellers" and "(the) two new members" form a binary quantifier. In sec. 6.3.3.2, we will see, with the qualifications noted there, that those logical forms which obtain truth in (421) through a binary quantifier also obtain it in (432).

6.3.3.1

The logical forms in the first case include all possible choices for the types of variables found in positions α_1 and α_2 in (441).

(441) 3 atms(α_1) [(the)2(y):nw mmbr(y)] 2! psswrds(α_2) atms(α_1) gave nw mmbr(y)
psswrds(α_2)

We discuss the most interesting choice where, they are both variables over sets:

(442) [3 atms(X)][the2y:nw mmbr(y)][2! psswrds(Z)] atms(X) gave nw mmbr(y)
psswrds(Z)

Keep in mind that the formula in (442) is part of our general way of talking about set-denotative logic which is indifferent to whether there is also a place for events.

95. As in n.91, the context includes (429) just to falsify the irrelevant event-dependent interpretation of (420).

We have set aside events and their interactions with sets and individual objects in order to include in our discussion any set-denotative logic that makes the minimal assumption that atomic predicates with places for sets and individual objects express true relations between them. As in (435)-(438) (p.220), the atomic predicate "automatic tellers(X) give new member(y) passwords(Z)" is true of automatic tellers A, new member m and passwords P only if A give m P. In this sense, the interpretation of an atomic predicate in any set-denotative logic expresses a true relation among sets and individual objects, whatever else it may say about events. So in the new logic's (440b) (p.220), the atomic predicate "automatic tellers(X,i) give new member(y) passwords(Z,j)" is true of automatic tellers A, new member m, passwords P and event i only if A give m P. In the following discussion, we show that if a logical form in set-denotative logic is free of n-ary quantifiers and its atomic predicate expresses a true relation, then its interpretation is not true in the context that includes (421) and (429)⁹⁶. That interpretation of (420) which is true in this context is therefore not represented within any such set-denotative logic. The set-denotative syntax, the absence of n-ary quantifiers and the expression of true relations are together sufficient for any resulting interpretation to have truth conditions that make it false in the context of (421) and (429).

We now show that no set of automatic tellers in (421) satisfies the formula in (443):

(443) [the2y: nw mmbr(y)][2! psswrds(Z)] atms(X) gave nw mmbr(y) psswrds(Z)

96. As in n.91, the context includes (429) just to falsify the irrelevant event-dependent interpretation of (420).

We consider those pairs of a set of automatic tellers and an individual new member that satisfy the formula in (444):

(444) $[2! \text{ psswrds}(Z)] \text{ atms}(X) \text{ gave nw mbr}(Y) \text{ psswrds}(Z)$

(445) $\text{atms}(X) \text{ give nw mbr}(Y) \text{ psswrds}(Z)$

We need to consider for each of the new members in (421) which automatic tellers gave him two passwords. There are only two pairs satisfying the formula: $\langle \{a_1\}, m_1 \rangle$ and $\langle \{a_2, a_3\}, m_2 \rangle$. The first automatic teller gave the first new member his two passwords. This state of affairs contributes to the extension of the atomic predicate (445) the three triples in (446), where it can be observed that a_1 and m_1 are related by exactly two passwords.

(446) $\langle \{a_1\}, m_1, \{p_1\} \rangle, \langle \{a_1\}, m_1, \{p_2\} \rangle, \langle \{a_1\}, m_1, \{p_1, p_2\} \rangle$

The second new member was given one of his passwords by the second automatic teller and the other password by the third teller. Thus, they, the two automatic tellers gave that new member the two passwords. Reflecting what happened to the second new member, the extension of (445) also contains the triples in (447):

(447) $\langle \{a_2, a_3\}, m_2, \{p_3, p_4\} \rangle, \langle \{a_2\}, m_2, \{p_3\} \rangle, \langle \{a_3\}, m_2, \{p_4\} \rangle$

One of the sets of automatic tellers, $\{a_2, a_3\}$, is related to m_2 by exactly two passwords thus accounting for the other pair that satisfies (444).

Among the pairs that fail to satisfy (444), we should mention in particular $\langle \{a_1, a_2, a_3\}, m_1 \rangle$ and $\langle \{a_1, a_2, a_3\}, m_2 \rangle$. Note that the second and third automatic tellers had nothing to do with giving the first new member passwords, and the first automatic teller had nothing to do with the second

new member.⁹⁷ Hence, (445) according to (438) is not true of $\{a_1, a_2, a_3\}$ and

97. As was first pointed out in n. 87, the point is not to deny that an atomic predicate such as (445) may have a usage according to which a set of automatic tellers is considered through some notion of collective action to have given a new member passwords even though some of the tellers do not appear to participate. In n. 87, we showed how for any given collective interpretation of the atomic predicate, we can reconstruct the context represented by a figure like (421) so that indeed automatic teller a_1 does not participate in a collective action towards new member m_2 , and automatic teller a_2 and a_3 do not participate in any collective action towards new member m_1 .

As in n. 87, the argument in the text will apply to any predicate " $\phi(X, c, D)$ " in the place of (445) which fails to have the property that if " $\phi(X, c, D)$ " is true, " $\phi(X', c, D)$ " is true for any superset X' of X . The simplest examples of such predicates are those whose interpretations have something for every individual in X to do. We have thus tried to provide examples with as physical or mechanical an interpretation as possible.

The figure in (421) represents mechanical interactions between individual member, password and automatic teller. We have already set up the context in its full description on p. 211, to anticipate and discourage the more obvious collective interpretations of the atomic predicate in (445). Recall that the tellers may be transmitting passwords for any number of Christmas clubs at any number of different banks. We can specify that in fact the two new members are enrolling in different clubs at different banks; and so the automatic tellers are not working with each other. It is false that the three automatic tellers give new member m_1 passwords p_1 and p_2 , or that they give new member m_2 passwords p_3 and p_4 . The pairs $\langle \{a_1, a_2, a_3\}, m_1 \rangle$ and $\langle \{a_1, a_2, a_3\}, m_2 \rangle$ would still fail to satisfy the formula in (444)¹ even if Christmas clubs had collective agents.

It suffices for the argument in the text that some interpretation of (445) and some context represented by (421) is such that the just mentioned pairs do not satisfy (445). Now looking more closely at collective interpretations for (445) for their own sake, I think many atomic sentences that would at first appear true under a collective interpretation of the predicate are quite odd when several aspects of the given context are considered. We have supposed that the second new member's two passwords enroll him in one particular Christmas club. The collective interpretation we are imagining for (445) seems at first to make it true that the second and third automatic tellers give him password p_3 and that they give him password p_4 . The extension of (445) would in addition to the list in (447) contain the triples in (448).

(448) $\langle \{a_2, a_3\}, m_2, \{p_3\} \rangle$, $\langle \{a_2, a_3\}, m_2, \{p_4\} \rangle$

Now recall that the location served by the three automatic tellers houses many tellers. Suppose that quite a few of the other automatic tellers serve

 the same Christmas club that m_2 is being enrolled in. The collective interpretation of giving passwords to new members in that Christmas club is certainly true of all the automatic tellers at that location working for that Christmas club, among which tellers a_2 and a_3 are just two.

Consider in particular new member m_2 and password p_3 . Concerning the mechanical details of the situation, automatic teller a_2 and only that teller gives that member that password. Concerning collective action, it is true that all the automatic tellers working for that Christmas club give that member that password. What seems to be an odd description of the collective action in this context is to assert for any proper subset (that includes a_2) of the tellers working for that Christmas club that they as well gave that member that password. Describing the same thing that happened to member m_2 and password p_3 , we would have a sequence of true atomic sentences paraphrased by: they, $\{a_2, a_3\}$, give it to him, they, $\{a_2, a_1\}$ gave it to him, they, $\{a_2, \dots\}$ give it to him..., supplying a long list of different collective agents for the same event. This does not sound correct.

Any given collective interpretation has some principle P defining which collections are collective agents. In any given context, it seems that a collective agent is always a maximal set, containing all the individuals in that context related by P. For the collective interpretation of (445), a collective agent is all the tellers at the location that work for a particular Christmas club. A different Christmas club corresponds to a different collective agent, unique for that club in the given context. If so, the extension of (445) in this context does not contain the triples in (448) even under its collective interpretation. (448) is replaced by (449), in which A^C is the true collective agent-- all the tellers at the location working for Christmas club C.

(449) $\langle A^C, m_2, \{p_3\} \rangle$, $\langle A^C, m_2, \{p_4\} \rangle$, $\langle A^C, m_2, \{p_3, p_4\} \rangle$

Now recall a further detail from the original description of this context. A new member who enters the location can use any of the automatic tellers to obtain one password at a time from any Christmas club. None of the tellers are dedicated to any clubs. They function indiscriminately, like telephones. The sentence in (420) is just a report of three automatic tellers being used when two new members each enroll in a Christmas club. In this context, A^C cannot be a proper subset of the automatic tellers at that location. All the automatic tellers are equally dedicated to Christmas club C. The context is set up to try to keep one from finding a notion of collective agent that picks out different groups of tellers within that location. Of course, one can still imagine a collective interpretation of (445) about the collective action of the automatic tellers at a given location. They are considered to have given a new member a password if the new member is given the password at their location. The given context then contains just one collective agent, and it is a proper superset of $\{a_1, a_2, a_3\}$. Under this collective interpretation, the extension of (445) in (421) would include none of the triples found in preceding examples, their first members being replaced by the set of all automatic tellers at the location. However sentences such as those in (450), which are not about all

m_1 for any set of passwords P , and it is not true of $\langle a_1, a_2, a_3 \rangle$ and m_2 for any set of passwords P .

As we have just seen, the only pairs in (421) satisfying the formula in (444) are $\langle \{a_1\}, m_1 \rangle$ and $\langle \{a_2, a_3\}, m_2 \rangle$. Obviously, there is no set of automatic tellers that pairs with two new members to satisfy (444). $\{a_1\}$ appears in a pair with only one new member m_1 , and $\{a_2, a_3\}$ is also paired with only one new member m_2 . Thus, there is no set of automatic tellers that satisfies the formula in (443), from which it follows that (442) is false in (421). Note that its falsity in (421) does not depend on whether we choose to interpret the quantifier "[3 atms(X)]" as having divided reference (i.e., according to (15b), (304b) or (314b) in the various set-denotative logics) or undivided reference (i.e., according to (15a), (304a) or (314a)). Divided reference permits the three automatic tellers to be distributed among possibly different sets of tellers that satisfy (443), and undivided reference requires that there be a set of three automatic tellers satisfying (443). Since, there are no sets in (421) satisfying (443), both interpretations are false.⁹⁸

the automatic tellers at the location, have interpretations that are true in the given context. [Of course (420) also has a true interpretation; but since we are showing that it cannot be represented by a logical form containing (445), we cite the simple sums of plurals in (450).]

(450) The two automatic tellers a_2 and a_3 gave the second new member two passwords
The three automatic tellers, a_1 , a_2 and a_3 , gave the two new members
the four passwords.

But, then the truth of those interpretations in the given context must not depend on an interpretation of the atomic predicate that uses a notion of collective agency.

98. The event-dependent interpretation of "[3 atms(X)]" ((16a), (305a) or (314a)), which says that any set that satisfies (443) is three automatic tellers, is vacuously true in (421) unless we add to the context the

As remarked earlier, (442) is the most interesting instance of (441). Other logical forms are obtained by letting α_1 or α_2 be a variable over individual objects. It should be clear that this will have an effect equivalent to eliminating from the extension of (445) those triples that contain non-singleton sets of automatic tellers or those triples that contain non-singleton sets of passwords. Then, these other logical forms will also represent interpretations false in (421). Since, what falsifies (442), viz., not enough automatic tellers in sets related to more than one new member, remains true when the extension of (445) is further reduced.

The sentence in (420) has an interpretation, represented in event logic by the logical form in (420), which is true in the context depicted in (421) (and in the context jointly depicted in (421) and (429)). Any set-denotative logical form for this interpretation would conform to (434). In the first case, we have considered all such logical forms that do not contain n-ary quantifiers, those conforming to (441). We have seen that none of these correctly represents the intended interpretation of (420). Their failure is they are true only if three automatic tellers each belong to some set or another that gives two passwords to each of the two new members. In (421), there is no set related to the individual new members in this way. Note however that the figure in (421) is an event in which the two new members are each given exactly two passwords and the givers in that event are three automatic tellers. This is sufficient for the relevant interpretation of

falsifying event in (429) in n. 91. This will add to the extension of (444) the pairs $\langle \{a_3\}, m_3 \rangle$ and $\langle \{a_3\}, m_4 \rangle$, but there are still not three automatic tellers in sets satisfying (443), and so the other interpretations of (442) remain false.

(420) to be true, and for its representation in event logic.

6.3.3.2

The second case of logical forms conforming to (434) includes those in which the outermost quantifiers form a binary quantifier (see sec. 2.4.1.).

(451) $[3 \text{ atms}(\alpha_1)]X[(\text{the})2y:\text{nw mbr}(y)] 2! \text{ psswrds}(\alpha_2) \text{ atms}(\alpha_1) \text{ give nw mbr}(y)$
 $\text{psswrds}(\alpha_2)$

Since other choices for α_1 and α_2 in fact lead to interpretations false in (421), we will need to discuss only that instance of (451) where both α_1 and α_2 are variables over sets:

(452) $[3 \text{ atms}(X)]X[(\text{the})2y:\text{nw mbr}(y)] [2! \text{ psswrds}(Z)] \text{ atms}(X) \text{ give nw mbr}(y)$
 $\text{psswrds}(Z)$

As in the preceding section, we will at first suppress quantification over events and consider any interpretation for the binary quantifier that includes at least the truth conditions in (453):

(453) " $[3 \text{ atms}(X)]X[(\text{the})2y:\text{new member}(y)] \Phi(X,y)$ " is true if and only if for sets C_1, \dots, C_k the union of which is three automatic tellers, and individuals d_1, \dots, d_k who are (the) two new members, " $\Phi(C_i, d_i)$ " is true for $1 \leq i \leq k$.

Note that (453) allows the binary quantifier to divide its reference among several sets of automatic tellers.⁹⁹

99. We need not consider undivided reference for the binary quantifier, as in (1). Interpreting the binary quantifier in (452) to have undivided reference to sets of automatic tellers results in an interpretation, equivalent to those in the preceding section, which is false in (421).

The binary quantifier in (453) allows the set-denotative logic to escape the difficulty undermining the logical forms of the preceding section. (452) interpreted according to (453) will not require there to be a set of automatic tellers that gives both new members their passwords. It suffices for various sets to contribute to this state of affairs if they are together three automatic tellers. The binary quantifier also appears to represent that part of the relevant interpretation of (420) which says that the two new members are each given exactly two passwords. The quantifier "exactly two passwords" has narrow scope in (452) and the variable x bound by the binary quantifier is still a variable over individuals. We thus first observe that, as required for (420), (452) interpreted according to (453) is indeed true in (421). The formula within the scope of the binary quantifier in (452) is the formula in (443). Recall that the extension of (444) in (421) consists of two pairs: $\langle\{a_1\}, m_1\rangle$ and $\langle\{a_2, a_3\}, m_2\rangle$. These are sufficient to satisfy the truth conditions of the binary quantifier in (453). Let C_1 be the set of automatic tellers $\{a_1\}$ and C_2 be the set of automatic tellers $\{a_2, a_3\}$. The union of C_1 and C_2 is three automatic tellers. The new members m_1 and m_2 are the two new members, d_1 and d_2 . As required, the formula (444) is true of C_1 and d_1 , and it is true of C_2 and d_2 . Hence, the logical form in (452) represents an interpretation that is true in (421).

We next observe that unlike any acceptable interpretation of the sentence in (420), the interpretation represented by (452) is also true in the context

(i) "[3 atms(X)]X[(the)2y:new member(y)] Φ (X,y)" is true if and only if for some set C which is three automatic tellers, and individuals d_1 and d_2 who are (the) two new members, " Φ (C, d_1)" is true and " Φ (C, d_2)" is true.

including (432) and (429). Recall from sec. 6.3.2 that the relevant interpretation of (420) is false in (432), no matter how that figure is partitioned into events. Recall in particular that if what happens in (432) is taken to be a single event of three automatic tellers giving new members passwords, the interpretation is false because that event fails to be one of two members each being given exactly two passwords. One of the new members m_1 is given four passwords.

In the logical form in (452), the quantifier, "[2! passwords(Z)]", within the scope of the binary quantifier, is not simply a measure of what each new member is given. The binary quantifier quantifies over pairs that satisfy the formula (444), which is true of a set of automatic tellers and an individual new member just in case exactly two passwords is what that set gave that new member. The interpretation represented by (452) allows a new member to receive two passwords from each set of automatic tellers. Note in particular that (444) is satisfied by the pairs in (454):

(454) $\langle \{a_1\}, m_1 \rangle, \langle \{a_2, a_3\}, m_1 \rangle, \langle \{a_3\}, m_2 \rangle$

Although new member m_1 is given four passwords, he is given exactly two by the first automatic teller and exactly two by the first and second automatic tellers. Since, the union of the sets of automatic tellers in (454) is three automatic tellers and the new members are the two new members, the interpretation represented by (452) is thus true in (432) (and in the context including (432) and (429)).

What has been shown so far is that an interpretation derived from binary quantification and an atomic predicate expressing the minimal true relation on sets and individual objects has truth conditions weak enough for the

interpretation to be true in (421) and (429), but they are also so weak that it is true in (432) and (429) as well.

(445) $\text{atms}(X)$ give nw $\text{mbr}(y)$ $\text{psswrds}(Z)$

The atomic predicate (445) has been interpreted to have only the truth conditions common to all set-denotative logics, those conditions characteristic of a true relation on sets of automatic tellers, individual new members and sets of passwords. We must now consider whether the conditions on events in some set-denotative interpretations, which have so far been suppressed, will help obtain an interpretation that is false in (432) while remaining true in (421). Consider for example how (452) looks in the new logic:

(455) $[\exists \text{atms}(\langle X, i \rangle)]X[(\text{the})_2 y: \text{nw mbr}(y)][\exists \text{psswrds}(\langle Z, j \rangle)]$
 $\text{atms}(\langle X, i \rangle) \text{ gave nw mbr}(y) \text{ psswrds}(\langle Z, j \rangle)$

The two place where we might vary the truth conditions on events are in the definition of the binary quantifier and that of the atomic predicate. We will find that none of the truth conditions on events allow (455) and similar logical forms to always represent an appropriate interpretation-- one that is true in contexts like (421) and (429) and false in contexts like (432) and (429).

The binary quantifier in order to obtain truth in (421) and (429) must divide its reference to sets of automatic tellers. Introducing events (i.e., the event-indexed sets) in (455), we can choose between divided reference to events as in (456) and undivided reference to events as in (457).

(456) (divided reference to event-indexed sets)

" $[\exists \text{atms}(\langle X, i \rangle)]X[(\text{the})_2 y: \text{new member}(y)] \diamond (\langle X, i \rangle, y)$ " is true if and only if

for some event-indexed sets $\langle C_1, i_1 \rangle, \dots, \langle C_k, i_k \rangle$, for which the union of C_1, \dots, C_k is three automatic tellers, and for individuals d_1, \dots, d_k who are (the) two new members, " $\Phi(\langle C_j, i_j \rangle, d_j)$ " is true for $1 \leq j \leq k$.

(457) (divided reference to sets, undivided reference to events)

" $[3 \text{ atms}(\langle X, i \rangle)]X[(\text{the})2y:\text{new member}(\langle y \rangle)] \Phi(\langle X, i \rangle, y)$ " is true if and only if for some event E , event-indexed sets $\langle C_1, E \rangle, \dots, \langle C_k, E \rangle$, for which the union of C_1, \dots, C_k is three automatic tellers, and for individuals d_1, \dots, d_k who are (the) two new members, " $\Phi(\langle C_j, E \rangle, d_j)$ " is true for $1 \leq j \leq k$.

In the truth conditions for the atomic predicate, we consider the clauses that have been labelled "event structure" in earlier examples (e.g. (439), p.220). Recall that these clauses impose the restriction from sec. 5.1 that only those sets are denoted which exhaust the participants in the event. In formulating this restriction, we did not consider the kind of atomic predicate found in (455) which contains a variable over individual objects along with the variables over sets. There are essentially three ways in which the restriction can hold of this kind of predicate. First, it may hold, as first formulated, to exhaust the participants of the event, as in (458). The atomic predicate is true of a set of automatic tellers, a new member, a set of passwords and an event only if that set of automatic tellers is all the automatic tellers giving new members passwords in that event and that set of passwords is all the passwords being given to new members in that event.

(458) "automatic tellers($\langle A, i \rangle$) give new member(m) passwords($\langle P, j \rangle$)" is true iff i. (relational str) automatic tellers A give new member m passwords P , and (event str) ii. $i=j$, & automatic tellers A give new member m passwords P at i , and iii. for all sets X, Y and Z ,
if automatic tellers X give new members Y passwords Z at i , then $X \subseteq A$ and $Z \subseteq P$.

Second, the restriction from sec. 5.1 may not constrain predicates with variables over individual objects, as in (459):

(459) "automatic tellers($\langle A, i \rangle$) give new member(m) passwords($\langle P, j \rangle$)" is true iff
i. (relational str) automatic tellers A give new member m passwords P , and
(event str) ii. $i=j$, & automatic tellers A give new member m passwords P at i .

Or third, the restriction may be relativized to values of the individual variables, as in (460), so that sets are denoted only if they exhaust what happened to some individual.

(460) "automatic tellers($\langle A, i \rangle$) give new member(m) passwords($\langle P, j \rangle$)" is true iff
i. (relational str) automatic tellers A give new member m passwords P , and
(event str) ii. $i=j$, & automatic tellers A give new member m passwords P at i ,
and iii. for all sets X and Z ,
if automatic tellers X give new member m passwords Z at i , then $X \subseteq A$ and $Z \subseteq P$.

Interpretations of (455) derived from (458) or (459) fail in an obvious way. An interpretation derived from (458) will be false of the event in (421). According to (458), the only denotable set of automatic tellers in the event is $\{a_1, a_2, a_3\}$, and we have seen earlier that this set does not give passwords either to new member m_1 or to new member m_2 . An interpretation derived from (459) fails to be false of the event in (432). It fails for the same reason as the interpretation of (452) did, since the mention of events imposes no relevant truth conditions. This leaves only those interpretations of (455) derived from combinations of (456) and (457) with (460).

We will see shortly that one of these combinations, the binary quantifier in (457) with the atomic predicate in (460) in fact represents the relevant interpretation of (420) which is true in (421) and (429) and false in (432) and (429). To finally show that the set-denotative logic cannot represent the class of interpretations which includes (420)'s, we will have to introduce somewhat different but closely related sentences. We first show

the limited success of set-denotative logic in representing in some way the relevant interpretation of (420).

Recall that the logical form in (452) interpreted according to (453) came out true in (432) and (429) because of the pairs in (454), which satisfy the formula in (444).

(454) $\langle \langle a_1 \rangle, m_1 \rangle, \langle \langle a_2, a_3 \rangle, m_1 \rangle, \langle \langle a_3 \rangle, m_2 \rangle$

(444) [2! psswrds(Z)] atms(X) gave nw mabr(y) psswrds(Z)

Note that, if the figure in (432) is taken to be a single event E, the truth conditions for the atomic predicate in (460) essentially eliminate the first two pairs in (454). The corresponding pairs in the new logic, $\langle \langle \langle a_1 \rangle, E \rangle, m_1 \rangle$ and $\langle \langle \langle a_2, a_3 \rangle, E \rangle, m_1 \rangle$, do not satisfy the formula in (461).
 (461) [2! psswrds(Z, j)] atms(X, i) gave nw mabr(y) psswrds(Z, j)

The result will be that the interpretation represented by (455) is false in (432) if there is just one event. For if the figure in (432) is the one event E, the extension of the atomic predicate, interpreted as in (460), is only the two triples in (462):

(462) $\langle \langle \langle a_1, a_2, a_3 \rangle, E \rangle, m_1, \langle \langle p_1, p_2, p_3, p_4 \rangle, E \rangle \rangle$

$\langle \langle \langle a_3 \rangle, E \rangle, m_2, \langle \langle p_5, p_6 \rangle, E \rangle \rangle$

(463) $\langle \langle \langle a_1 \rangle, E \rangle, m_1, \langle \langle p_1, p_2 \rangle, E \rangle \rangle, \langle \langle \langle a_2, a_3 \rangle, E \rangle, m_1, \langle \langle p_3, p_4 \rangle, E \rangle \rangle$

In particular, the extension does not contain the triples in (463), since neither set of automatic tellers exhausts the automatic tellers giving passwords to m_1 , and neither set of passwords exhausts the passwords given to m_1 in E. Since, the triples in (463) do not belong to the extension of the atomic predicate, the pairs $\langle \langle \langle a_1 \rangle, E \rangle, m_1 \rangle$ and $\langle \langle \langle a_2, a_3 \rangle, E \rangle, m_1 \rangle$ do not satisfy

(461). Moreover, the pair $\langle \langle \{a_1, a_2, a_3\}, E \rangle, m_1 \rangle$ does not satisfy the formula since the set of automatic tellers gives m_1 four passwords. Thus, there are not three automatic tellers in E or two new members with the required properties. The truth conditions on events that appear in (460) are sufficient to make the interpretation of (455) false in (432) if (432) is taken to be a single event.

But, recall that any acceptable interpretation of (420) is false in the context of (432) and (429), no matter how we partition (432) into events. Compare now the extension of the atomic predicate if it is partitioned into the two events shown in (433). Let the upper one be E_1 , and the lower, E_2 . The extension of the predicate in (433) is (464), in which the sets shown exhaust what happened to the individual new member in the indicated event.

$$(464) \quad \langle \langle \{a_1\}, E_1 \rangle, m_1, \langle \{p_1, p_2\}, E_1 \rangle \rangle \\ \langle \langle \{a_2, a_3\}, E_2 \rangle, m_1, \langle \{p_3, p_4\}, E_2 \rangle \rangle, \quad \langle \langle \{a_3\}, E_2 \rangle, m_2, \langle \{p_5, p_6\}, E_2 \rangle \rangle$$

One finds in (464), the pairs in (465), each related by exactly two passwords and therefore satisfying the formula in (461).

$$(465) \quad \langle \langle \{a_1\}, E_1 \rangle, m_1 \rangle, \quad \langle \langle \{a_2, a_3\}, E_2 \rangle, m_1 \rangle, \quad \langle \langle \{a_3\}, E_2 \rangle, m_2 \rangle$$

Notice that the automatic tellers in these pairs are three, and the new members are two.

The truth conditions contributed by the atomic predicate in (460) are not sufficient to falsify the interpretation of (455) in all the contexts derived from what happened in (432) and (429). In particular, an interpretation true in (433) is obtained if the binary quantifier is interpreted according to (456) to have divided reference to events. That interpretation is verified

by the pairs in (465). We do however obtain an interpretation of (455) that is false in all the contexts derived from (432) if the interpretation of the atomic predicate in (460) is combined with the binary quantifier in (457), which has undivided reference to events. For if the figure in (432) is to be a single event, then (455) will be false for the reasons given above. If it is partitioned into more than one event, then no one of them will contain enough automatic tellers and new members to meet the requirements of the binary quantifier in (457). It is easy to verify that the interpretation of (455) obtained from (460) and (457) is still true in (421), as is also required for the intended interpretation of the sentence in (420).

It should now be clear how the devices of (460) and (457) make it possible for set-denotative logic to represent the various aspects of the relevant interpretation of (420). Binary quantification allows it to say that there are three automatic tellers and (the) two new members, without saying that a particular set of automatic tellers gives both of the new members their passwords. The particular binary quantifier in (457) allows the interpretation to be about one single event without requiring it to be about one set of automatic tellers. And the condition from sec. 5.1 relativized to individual variables requires that what is said about an individual new member is about all that happened to him in that event. Thus, if there is some set of automatic tellers that is said to give him exactly two passwords, then he is given exactly two passwords in that event, which eliminates the problem arising from the position of "[2! passwords(<2,j>)]" within the scope of both "three automatic tellers" and "<the> two new members".

We have not given a systematic presentation of binary quantifiers, which a

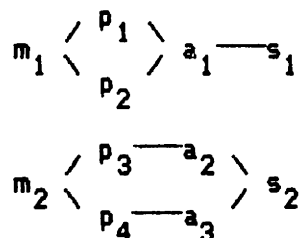
set-denotative logic including them would have to do. One apparent peculiarity is that it would contain the binary quantifier in (457) but would have to exclude the one in (456). Otherwise, the set-denotative logic would again fail by assigning (420) an interpretation true in the context including the two events of (433) and the one in (429).¹⁰⁰ We have also not stopped to consider the full range of interpretations that are assigned when binary quantifiers have scope interactions with each other and in more complicated ways with unary quantifiers. We will instead finally dispose of set-denotative logic more directly, by showing that the devices proposed for (420), the binary quantifier in (457) and the relativized restriction from sec. 5.1 ultimately fail.

Consider the sentences in (466).

(466) Three automatic tellers gave the two new members exactly two passwords on a slip of pink paper.

Three automatic tellers gave the two new members on a slip of pink paper exactly two passwords each.

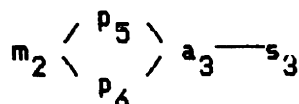
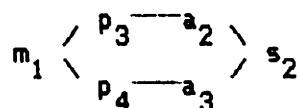
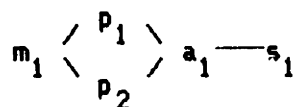
(467) (Cf. (421))



100. Sec. 2.4.1 discusses two kinds of interpretations that suggest the need for binary quantifiers in set-denotative logic. However, they suggest the need for binary quantifiers with divided reference to both sets and events as in (456). For example, Scha's cumulative quantification in (i) is true only if exactly 500 Dutch firms are in events of Dutch firms buying American computers and exactly 600 American computers are in such events.

(i) Exactly 500 Dutch firms bought exactly 600 American computers

(468) (Cf. (432))



These sentences are identical to (420) but for the added argument "a slip of pink paper". The contexts represented by (467) and (468) correspond respectively to (421) and (432), and they are to be interpreted in the same way. Recall that passwords are given to new members one at a time. The new member enters a new request at some automatic teller for each password. Suppose also that the new member can have his password printed on a fresh slip of paper or he can present to the automatic teller a slip of paper already in his possession. The figure in (467) shows that new member m_1 had automatic teller a_1 give him his two passwords on one slip of pink paper s_1 . New member m_2 had one password given to him by the automatic teller a_2 on the slip of pink paper s_2 and his other password given to him by automatic teller a_3 on the same slip of paper. The figure in (468) is similarly interpreted; s_1 , s_2 and s_3 are three distinct slips of pink paper.

The sentences in (466) have an interpretation, represented in event logic by (469), which is true in (467) and false in (468).

(469)

[Ee give(e):[the2(y,e):nw mmbr(y)] TO(e,y) OF(e, 2!pswrds) on(e, a slp pnk ppr)]
INFL(e, 3 atms)¹⁰

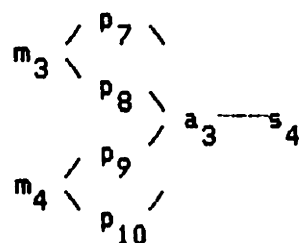
101. The logical forms under (i) and (ii) in which "the two passwords" or "a slip of paper" are complex quantifiers over individuals within the scope of

We now show that the set-denotative treatment of (420) will not extend to the relevant interpretation of (466). It results in interpretations of (466) that are inappropriately true in (468)¹⁰². The set-denotative logic assigns to (466) a logical form, among others, which is like (455) and where the new NP "a slip of pink paper" binds a variable over individual objects, as in (471) or (472).

(472) [3 atms($\langle X, i \rangle$)]X[(the) $2y$:nw mmbr(y)] [Ew: pnk slp(w)] [2! psswrds($\langle Z, j \rangle$)]
atms($\langle X, i \rangle$) gave nw mmbr(y) psswrds($\langle Z, j \rangle$) on slp of pnk ppr(w)

(i) [Ee give(e):[the2<y,e>:nw mmbr(y)]...[2!<z,e>:psswrd(z)]...] INFL(e, 3 atms)
(ii) [Ee give(e):[the2<y,e>:nw mmbr(y)]...[E<w,e>:pnk slp(w)]...] INFL(e, 3 atms)

(470)



The binary quantifier in (471) and (472) is interpreted by (457), as it was in that interpretation of (455) which turned out to be correctly false in all the contexts derived from (432).

The atomic predicate in (471) and (472) is (473):

(473) $\text{atms}(\langle X, i \rangle)$ gave nw mmbr(y) psswrds($\langle Z, j \rangle$) on slp of pnk ppr(w)

The restriction from sec. 5.1 relativized to individual variables will, when relativized to both individual variables in (473), result in an interpretation with the truth conditions in (474):

(474) " $\text{atms}(\langle A, i \rangle)$ give nw mmbr(m) psswrds($\langle P, j \rangle$) on slp of pnk ppr(s)"
is true iff

i. (relational str) automatic tellers A give new member m passwords P on slip of pink paper s, and

(event str) ii. $i=j$, &

automatic tellers A give new member m passwords P on slip of pink paper s at i, and iii. for all sets X and Z, if

automatic tellers X give new member m passwords Z on slip of pink paper s at i, then $X \subseteq A$ and $Z \subseteq P$.

According to (474), a set of automatic tellers gives a set of passwords to an individual new member on a slip of pink paper in an event if and only if that set of tellers is all the automatic tellers giving passwords to that individual new member on that slip of pink paper in that event and that set of passwords is all the passwords being given by automatic tellers to that new member on that slip of paper in that event. Let us take the figure in (468) to be the single event E. The extension in (468) of the atomic predicate according to is (475):

(475) $\langle \langle a_1 \rangle, E \rangle, m_1, \langle \langle p_1, p_2 \rangle, E \rangle, s_1 \rangle$

$\langle \langle a_2, a_3 \rangle, E \rangle, m_1, \langle \langle p_3, p_4 \rangle, E \rangle, s_2 \rangle$

$\langle \langle a_3 \rangle, E \rangle, m_2, \langle \langle p_5, p_6 \rangle, E \rangle, s_3 \rangle$

Each quadruple in (475) exhausts what happened in E. (468), on some slip of pink paper for some new member.

(476) $\langle \langle \langle a_1 \rangle, E \rangle, m_1 \rangle, \langle \langle \langle a_2, a_3 \rangle, E \rangle, m_1 \rangle, \langle \langle \langle a_3 \rangle, E \rangle, m_2 \rangle$

(477) $[2! \text{ psswrds}(\langle Z, j \rangle)] [Ew: \text{pnk slp}(w)]$
 $\text{atms}(\langle X, i \rangle) \text{ gave nw mmbr}(y) \text{ psswrds}(\langle Z, j \rangle) \text{ on slp of pnk ppr}(w)$

(478) $[Ew: \text{pnk slp}(w)] [2! \text{ psswrds}(\langle Z, j \rangle)]$
 $\text{atms}(\langle X, i \rangle) \text{ gave nw mmbr}(y) \text{ psswrds}(\langle Z, j \rangle) \text{ on slp of pnk ppr}(w)$

It is obvious that the pairs in (476) satisfy both formulas in (477) and (478) and that there are enough automatic tellers and new members in E so that (471) and (472) are true even with the binary quantifier in (457).

One might wish for the restriction from sec. 5.1 to be relativized to only one of the individual variables. There being no principled choice between them, one interpretation of the atomic predicate would relativize the restriction to the variable bound by "a slip of pink paper", as in (479):

(479) "atms($\langle A, i \rangle$) give nw mmbr(m) psswrds($\langle P, j \rangle$) on slp of pnk ppr(s)" is true iff

i. (relational str) automatic tellers A give new member m passwords P on slip of pink paper s, and

(event str) ii. $i=j$, &

automatic tellers A give new member m passwords P on slip of pink paper s at i, and iii. for all sets X, Y and Z, if

automatic tellers X give new members Y passwords Z on slip of pink paper s at i, then $X \subseteq A$ and $Z \subseteq P$.

But, the extension in (468) of this interpretation of the atomic predicate is also the quadruples in (475), and (471) and (472) are again true in (468). Thus, the set-denotative logic will always assign some interpretation to (466) that is unacceptably true in the context including (468) and (470) (see

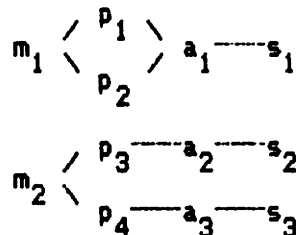
We have thus seen that the set-denotative treatment of the relevant interpretation of (420), binary quantification according to (457) and the restriction from sec. 5.1 relativized to individual variables, does not extend to the interpretation of (466). It will in general fail on those set-denotative logical forms with more than one variable over individual objects.

Sec. 6.3, like sec. 6.2, has shown a failure in interpretation that is a consequence of the syntax of set-denotative logic and the assumption that atomic predicates express true relations among their arguments. As we have seen, event logic assigned the correct interpretations.

The syntax of set-denotative logic requires that any formula that contains an atomic predicate "V" also contains a place for every argument. In particular, set-denotative counterparts to the event logic's (428) must

103. The reader is left to check the following. The sentences in (466) have an interpretation, represented in the event logic by (480) (one of the logical forms under (i) and (ii) in n.101), which is true in (467) and the slightly altered context in (481). If the restriction from sec. 5.1. is relativized to either or both of the individual variables, then no interpretation of (471) is true in (480). Thus, the set-denotative logic would fail to represent an acceptable interpretation of (466) as well as assigning it an unacceptable one.

(480) [Ee give(e):[the2(y,e):nw mmbr(y)] TO(e,y)
[2!(z,e):pswrd(z)] OF(e,z) on(e, a pnk slp)] INFL(e, 3 atms)
(481)



contain a place for the variable \underline{X} :

(428) $[V(e) [(the)2\langle y, e \rangle : N'(\langle y \rangle)] R(e, y) S(e, 2! N')]$

(430) $[(the)2y : N'(\langle y \rangle)] [2! N'(\langle Z, j \rangle)] V(\langle X, i \rangle, y, \langle Z, j \rangle)$

(431) $[(the)2y : N'(\langle y \rangle)] [2! N'(Z)] V(X, e, y, Z)$

The relevant interpretations of (420) and (466) assert the existence of an event in which two new members are each given exactly two passwords by automatic tellers. The NP "exactly two passwords" measures what happened to the individual new member in the event. But, the set-denotative formulas, because of the place for \underline{X} , do not allow an event to be characterized in this way. They are about only what particular sets of automatic tellers did to the new members. The binary quantifier in (457) allows talk about a single event and what several distinct sets of automatic tellers did. But, the quantifier "exactly two passwords" measures not the totality of what happened in the event to the individual new member but what each of possibly several sets of automatic tellers did to him there. We have also seen that what happens to the individual new member does not always coincide with an n-tuple denoted by the atomic predicate. It fails when the atomic predicate contains another variable over individual objects, as in (471) and (472). In the situation constructed in (468), the set of automatic tellers that gives m_1 all his passwords, $\{a_1, a_2, a_3\}$, does not do it on some individual slip of pink paper.¹⁰⁴ Although four passwords is given to m_1 in this event, there is no set of automatic tellers that appears with m_1 and four passwords in n-tuples in the extension of the atomic predicate.

104. $\{a_1, a_2, a_3\}$ gives m_1 passwords $\{p_1, p_2, p_3, p_4\}$ on slips of pink paper $\{s_1, s_2\}$.

6.4

Our point has been to show that the syntax of set-denotative logic is untenable. It maintains that plurals are always quantifiers either over sets or individuals and that they bind into atomic polyadic predicates. One possible way out for the set-denotative logic from the problems of sec. 6.2 and 6.3 tries to keep its syntax while taking from event logic some assumptions about interpretation. We consider this way out in order to pursue the syntactic point that variables over sets and atomic polyadic predicates are untenable.

The possible way out for set-denotative logic is to admit in the lexicon a Davidsonian decomposition of polyadic predicates. It comes in only to regiment how the atomic predicates are interpreted, affecting what has been labelled "relational structure" in their truth conditions. The characteristic syntax of set-denotative logic is unchanged.

Recall that the clauses labelled "relational structure" have always contained the truth conditions appropriate to a predicate that expresses a true relation among its arguments. The predicate "senators($\langle C, i \rangle$) speak in favor of amendment(d)" expresses a true relation in the sense that if it is true of a set of senators and an amendment, then their speeches (at i) are indeed in favor of that particular amendment. We now replace the truly relational with truth conditions such as those illustrated below under clause i.

(482) "senators($\langle C, i \rangle$) speak in favor of amendment(d)" is true iff

- i. (relational structure) senators C speak in favor of amendments at i , and
senators speak in favor of amendment d at i , and
- (event structure) iii. for all sets X ,
if senators X speak in favor of amendments at i , then XCC .

(483) "billiard balls($\langle C, i \rangle$) bounce off side(d) of the pool table" is true iff
i. (relational structure) billiard balls C bounce off sides of the pool table at i , and
and billiard balls bounce off side of the pool table d at i , and
(event structure) iii. for all sets X ,
if billiard balls X bounce off sides at i , then XCC .

(484) "automatic tellers($\langle A, i \rangle$) give new member(m) password(p)" is true iff
i. (relational str) automatic tellers A give new members passwords at i , and
automatic tellers give new member m password p at i , and
(event str) iii. for all sets X , Y and Z ,
if automatic tellers X give new members Y passwords Z at i , then XCA .

(485) "automatic tellers($\langle A, i \rangle$) give new member(m) passwords($\langle P, j \rangle$)" is true iff
i. (relational str) automatic tellers A give new members passwords at i , and
automatic tellers give new member m passwords at i , and
automatic tellers give new members passwords P at i , and
(event str) ii. $i=j$, and
iii. for all sets X , Y and Z ,
if automatic tellers X give new members Y passwords Z at i , then XCA and ZCP .

(482)-(484) are from the following schema. It is assumed that any n -ary atomic predicate is associated with a true (in the above sense) relation on sets " $\Phi^*(\alpha_1, \dots, \alpha_n)$ ". Corresponding to such a relation, there are 2^n distinct atomic predicates distinguished by whether they have a variable over individuals or a variable over event-indexed sets in each of the n argument places. Now suppose for one of these predicates that its variables over individuals are x_1, \dots, x_j and its variables over event-indexed sets are $\langle Y_k, e_k \rangle, \dots, \langle Y_1, e_1 \rangle$. The predicate has the truth conditions in (486):

(486) " $\Phi^*(c_1, \dots, c_j, \langle D_k, e_k \rangle, \dots, \langle D_1, e_1 \rangle)$ " is true iff
i. (relational structure)
a. there exist (non-empty) sets $S_1, \dots, S_j, T_{k+1}, \dots, T_1$ such that
 $\Phi^*(S_1, \dots, S_j, D_k, T_{k+1}, \dots, T_1)$ at e_k ; and...
there exist (non-empty) sets $S_1, \dots, S_j, T_k, \dots, T_{1-1}$ such that
 $\Phi^*(S_1, \dots, S_j, T_k, \dots, T_{1-1}, D_1)$ at e_k ; and

- b. there exist (non-empty) sets T_k, \dots, T_1 such that
- $\Phi^*(\langle c_i \rangle, \dots, \langle c_j \rangle, T_k, \dots, T_1)$ at e_k ; and
- (event structure) ii. $e_k = \dots = e_1$, and
- iii. for all sets $S_i, \dots, S_j, T_k, \dots, T_1$,
- if $\Phi^*(S_i, \dots, S_j, T_k, \dots, T_1)$ at e_k , then $T_k \subseteq D_k$ and...and $T_1 \subseteq D_1$.

As before, a predicate denotes an n-tuple of event-indexed sets and individuals just in case the sets in the n-tuple exhaust for their roles the participants in some event (clauses i, ii and iii). There is now however no true relation between the sets of the n-tuple and the individuals. We do not require that $\Phi^*(\langle c_i \rangle, \dots, \langle c_j \rangle, D_k, \dots, D_1)$ in that event. It is sufficient according to clause (i.b) for the individuals to be related to some of the participants in the event. The relation between an individual and a set in the denoted n-tuple is reduced to that of belonging to the same event.¹⁰⁵

105. Note that clause (i.b) in (486) cannot be formulated as (i.b'):

(i.b') there exist (non-empty) sets $S_{i+1}, \dots, S_j, T_k, \dots, T_1$ such that

$\Phi^*(\langle c_i \rangle, S_{i+1}, \dots, S_j, T_k, \dots, T_1)$ at e_k , and...

and there exist (non-empty) sets $S_i, \dots, S_{j-1}, T_k, \dots, T_1$ such that

$\Phi^*(S_i, \dots, S_{j-1}, \langle c_j \rangle, T_k, \dots, T_1)$ at e_k

(i.b') only requires each individual in the denoted n-tuple to have been Φ^* -ed in the event. Our (i.b) requires the individuals in the n-tuple to be related by Φ^* to each other, although not to any of the sets in the n-tuple. This is necessary for those interpretations that make essential use of individual variables to represent scope interactions:

(i) Few critics each bought three good books

(ii) [Few critics(x)][three good books(y)] critic(x) bought good book(y)

If the atomic predicate in (ii) with two individual variables were interpreted by (i.b'), it would come out equivalent to (v) and therefore to (vi):

nine members, the interpretations of (382) are falsified, as required. 106

When the atomic predicate expresses a true relation, we observed in sec. 6.3 that the logical forms in (439) represent interpretations that are false in the context of (421), although the relevant interpretation of (420) is true there:

(420) Three automatic tellers gave (the) two new members exactly two passwords (each)

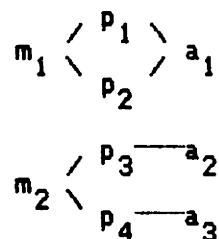
(439) a:

[3 atms($\langle X, i \rangle$)] [$\langle \text{the} \rangle 2y: \text{nw mbr}(y)$] [$2! z: \text{psswr}(z)$] atms($\langle X, i \rangle$) gave nw mbr(y) psswr(z)

(439) b:

[3 atms($\langle X, i \rangle$)] [$\langle \text{the} \rangle 2y: \text{nw mbr}(y)$] [$2! \text{psswrds}(\langle Z, j \rangle)$] atms($\langle X, i \rangle$) gave nw mbr(y) psswrds($\langle Z, j \rangle$)

(421)



106. Recall from the excursus in sec. 6.1.1 that (344) may misinterpret (341):

(341) Two boys danced with two girls.

(344) [$2 \text{ girls}(\langle Y, j \rangle)$] [$2x: \text{boy}(x)$] boy(x) danced with girls($\langle Y, j \rangle$)

(344) required that each of two boys danced with the same group of two girls.

(487) "boy(c) danced with girls($\langle D, j \rangle$)" is true iff

- i. (relational str) boy c dance with girls at i , and
boys dance with girls D at i , and
- (event str) iii. for all sets X and Y ,
if boys X dance with girls Y at i , then YCD .

Now interpreting the atomic predicate according (487), each of two boys are required only to have danced with girls at the event at which two girls danced with boys. But, this is equivalent to the sum of plurals interpretation of (341), which is of course acceptable.

Reinterpreting the atomic predicates in (439) according to (485) and (484) yields the following extensions in (421), assuming it depicts the event E.

(488) ((484)) $\langle \langle \{a_1, a_2, a_3\}, E \rangle, m_1, p_1 \rangle, \langle \langle \{a_1, a_2, a_3\}, E \rangle, m_1, p_2 \rangle$

$\langle \langle \{a_1, a_2, a_3\}, E \rangle, m_2, p_3 \rangle, \langle \langle \{a_1, a_2, a_3\}, E \rangle, m_2, p_4 \rangle$

(489) ((485)) $\langle \langle \{a_1, a_2, a_3\}, E \rangle, m_1, \langle \{p_1, p_2, p_3, p_4\}, E \rangle \rangle$

$\langle \langle \{a_1, a_2, a_3\}, E \rangle, m_2, \langle \{p_1, p_2, p_3, p_4\}, E \rangle \rangle$

In (488), the three automatic tellers in the set $\{a_1, a_2, a_3\}$ give m_1 exactly two passwords, and they give m_2 exactly two passwords. Thus, (439a) represents in set-denotative logic an interpretation of (420) that is true in (421).¹⁰⁷ Moreover, both logical forms in (439) represent interpretations that are false where required. They are false in the context of (432) and (429). The extension of the atomic predicates in (432) show that the set of three automatic tellers is related to m_1 by more than two passwords:

(432)

$$m_1 \begin{array}{l} / p_1 \backslash \\ \backslash p_2 / \end{array} a_1$$

$$m_1 \begin{array}{l} / p_3 \text{---} a_2 \\ \backslash p_4 \text{---} a_3 \end{array}$$

$$m_2 \begin{array}{l} / p_5 \backslash \\ \backslash p_6 / \end{array} a_3$$

(490) ((484)) $\langle \langle \{a_1, a_2, a_3\}, E \rangle, m_1, p_1 \rangle, \langle \langle \{a_1, a_2, a_3\}, E \rangle, m_1, p_2 \rangle$

$\langle \langle \{a_1, a_2, a_3\}, E \rangle, m_1, p_3 \rangle, \langle \langle \{a_1, a_2, a_3\}, E \rangle, m_1, p_4 \rangle$

$\langle \langle \{a_1, a_2, a_3\}, E \rangle, m_2, p_5 \rangle, \langle \langle \{a_1, a_2, a_3\}, E \rangle, m_2, p_6 \rangle$

(491) ((485)) $\langle \langle \{a_1, a_2, a_3\}, E \rangle, m_1, \langle \{p_1, p_2, p_3, p_4, p_5, p_6\}, E \rangle \rangle$

107. (439b) represents a false interpretation, as (489) indicates. The three automatic tellers are found giving each of the new members four passwords.

$$\langle \langle \{a_1, a_2, a_3\}, E \rangle, m_2, \langle \{p_1, p_2, p_3, p_4, p_5, p_6\}, E \rangle \rangle$$

We have thus seen how a Davidsonian decomposition in the lexicon provides a way out for set-denotative logic from the problems of sec. 6.2 and 6.3.¹⁰⁸ We however now find that the set-denotative logic fails elsewhere. It now fails on what was our first case of interpretations requiring an atomic predicate that mixed variables over individual objects with variables over sets (p.179). In this case, the quantifiers over individual objects include

108. The revised schema for denoting n-tuples of event-indexed sets and individuals gives rise to a problem analogous to one encountered in the event logic (see sec. 3.1.1.). Under the revised schema, the new logic misinterprets quite simple sentences, such as that in (492):

(492) These billiard balls bounced off that side of the pool table.
 [these billiard balls($\langle X, i \rangle$)] [that side(y)] billiard balls($\langle X, i \rangle$) bounced
 off side(y)

Note first that "[that side(y)]" is an increasing quantifier (only existential force). It does not in general mean "that side and only that side"; otherwise a sentence like (493) would have a common interpretation with the sentence in (494), an interpretation that excluded other sides from being bounced off:

(493) That side of the pool table was bounced off by billiard balls.

(494) That side and only that side of the pool table was bounced off by billiard balls.

The interpretation of (492) under the revised schema will then require only that these billiard balls be the only bouncers in some event in which that side of the pool table is bounced off of. Thus, (492) comes out true even if just one of these billiard balls bounced off that side and the others bounced off other sides.

Correct truth conditions would be obtained if in the context of (492), the quantifier "[that side(y)]" did mean "that side and only that side". Then, since there is only that side to bounce off of in the event, it must be that one that these billiard balls bounced off of. In setting aside this problem, we assume that the set-denotative logic can find an appropriate stipulation with the effect that any quantifier occurring within the scope of a quantifier over event-indexed sets, as in (492), acquires a non-increasing interpretation. As we have seen in sec. 3.1, such a stipulation was also required for the event logic in the face of a similar problem (see the asterisk notation in (63)-(65).

within their scope the quantifiers over sets:

(31) Three agents sold twenty-five buildings to two investors.

(328) Three agents each sold twenty-five buildings to two investors.¹⁰⁹

(329) $[3x: \text{agnt}(x)][25 \text{ bldgs}(\langle Y, i \rangle)][2 \text{ invstrs}(\langle Z, j \rangle)] \text{ agnt}(x) \text{ sold bldgs}(\langle Y, i \rangle)$
to $\text{invstrs}(\langle Z, j \rangle)$

(495) "agnt(b) sold bldgs($\langle C, i \rangle$) to invstrs($\langle D, j \rangle$)" is true iff

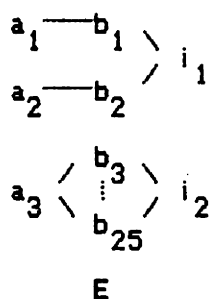
i. (relational str) agent b sells buildings to investors at i, and
agents sell buildings C to investors at i, and
agents sell buildings to investors D at i, and

(event structure) ii. $i=j$, and

iii. for all sets X, Y and Z,
if agents X sell buildings Y to investors Z at i, then $Y \subseteq C$ and $Z \subseteq D$.

Note that the interpretation of the logical form in (329) according to (495) results in an interpretation that is true if three agents are involved in some event of selling twenty-five buildings to two investors, even if, as in (496), the first two agents each sold one of the buildings and the third sold the remaining twenty-three. The triples in (497) satisfy the atomic predicate interpreted according to (495):

(496)



(497) $\langle a_1, \langle \{b_1, \dots, b_{25}\}, E \rangle, \langle \{i_1, i_2\}, E \rangle \rangle$

$\langle a_2, \langle \{b_1, \dots, b_{25}\}, E \rangle, \langle \{i_1, i_2\}, E \rangle \rangle$

$\langle a_3, \langle \{b_1, \dots, b_{25}\}, E \rangle, \langle \{i_1, i_2\}, E \rangle \rangle$

109. Also the example from n. 80:

(i) Three gerrymanderers (each) turned ten neighborhoods into eight electoral districts

It has become impossible to require the three agents to each sell twenty-five buildings to two investors-- an effect of having eliminated the expression of a true relation between sets and individuals in (495).

Importing additional apparatus from event logic will take us a step further in maintaining the set-denotative syntax. This step finds a set-denotative representation for the interpretation of (31) and (328) which was our first case requiring an atomic predicate that mixed variables over sets with variables over individual objects. But, it is a false step, leaving no way out from the problems of sec. 6.2 and 6.3. That is, the set-denotative logic, if this step is taken, will then again fail, as in sec. 6.2 and 6.3, on those logical forms in which a quantifier over individual objects does not include within its scope at least one of the quantifiers over sets --the second case where both types of variables are required (p.179).

Although assuming the Davidsonian decomposition in the lexicon, we can find a set-denotative representation for the relevant interpretation of (31) and (328) if we now assume with event logic that quantifiers over individual objects are in fact complex quantifiers over objects and events. As in event logic, we make use of a primitive semantic function " $I(x,E)$ ": $I(x,E)$ is what the individual object did alone in the context of events E . It is assumed that people have the cognitive ability to recognize in a domain of events what an individual has done there. The truth conditions for complex quantifiers will, using I , guarantee that each individual agent sells his own twenty-five buildings to two investors:

(498) " $[\exists(x,e):agent(x)] \Phi(x,e)$ " is true in E iff there are three agents a_1 , a_2 and a_3 such that " $\Phi(a_i, I(a_i,E))$ " is true in $I(a_i,E)$, for $1 \leq i \leq 3$.

To enable the complex quantifiers to bind the event place assumed in (498), we give up the new logic and event-indexed sets for the alternative in n.71. It has $n+1$ -ary predicates " $\Phi\langle X_1, \dots, X_n, e \rangle$ " instead of the new logic's n -ary predicates " $\Phi\langle \langle X_1, e_1 \rangle, \dots, \langle X_n, e_n \rangle \rangle$ ". The place for events is now bound by quantifiers over sets or quantifiers over individual objects. The quantifiers over sets are interpreted according to (313') and (314'):

(313') Increasing quantifiers.

- a. (undivided reference to a denotatum) "[Q N'] Φ " is true in E iff for some set C and some event i in E, C is [Q N']-many, and " $\Phi\langle C, i \rangle$ " is true in i.
- b. (divided reference) "[Q N'] Φ " is true in E iff for some sets C_1, \dots, C_k, \dots , and some events i_1, \dots, i_k, \dots in E, the union of C_1, \dots, C_k, \dots is [Q N']-many, and " $\Phi\langle C_1, i_1 \rangle$ " is true in i_1 ...and " $\Phi\langle C_k, i_k \rangle$ " is true in i_k

(314') Non-increasing quantifiers.

- a. (event-dependent) "[Q N'] Φ " is true in E iff every set C is such that if for some event i in E, C is involved in i and " $\Phi\langle C, i \rangle$ " is true in i, then C is [Q N']-many.
- b. (non-event-dependent) "[Q N'] Φ " is true in E iff the union of all sets C such that for some event i in E, C is involved in i and " $\Phi\langle C, i \rangle$ " is true in i is [Q N']-many.

110. As their interpretations in (498), (313') and (314') show, both quantifiers over individual objects and quantifiers over sets quantify over events. The difference in notation-- we have " $[Q\langle x, e \rangle; N'(x)]$ " and " $[Q N'(X)]$ " but neither " $[Qx; N'(x)]$ " nor " $[Q N'(X, e)]$ "-- is meant to signal the following difference in their interpretation. Recall from n.71 and the discussion in sec. 5.3 that within a prefix of quantifiers over sets, as in (i), the leftmost " $[Q N'(X_1)]$ " determines the value of the event variable.

(i) $[Q N'(X_1)] \Phi \langle \dots [Q N'(X_n)] P\langle X_1, \dots, X_n, e \rangle \rangle$

When the leftmost quantifier is interpreted according to (313') or (314'), the quantification over events, "for some event i...", chooses a value for the event variable, which is free in Φ in (i). In interpreting the quantifiers over sets with narrower scope, the quantification over events, "for some event i" is vacuous, since the event variable is replaced by the value determined by the leftmost quantifier. With the addition of complex quantifiers over individual objects, the quantification over events in (313')

Interpreting the logical form in (499) according to (498) and to the analogue of (495) in (500) will obtain the intended interpretation of (31) and (328):

(499) [3<x,e>:agnt(x)][25 bldgs(Y)][2 invstrs(Z)] agnt(x) sold(e) bldgs(Y)
to invstrs(Z)

(500) "agnt(b) sold(i) bldgs(C) to invstrs(D)" is true iff

- i. (relational str) agent b sells buildings to investors at i, and
 agents sell buildings C to investors at i, and
 agents sell buildings to investors D at i, and
- (event structure) iii. for all sets X, Y and Z,
 if agents X sell buildings Y to investors Z at i, then YCC and ZCD.

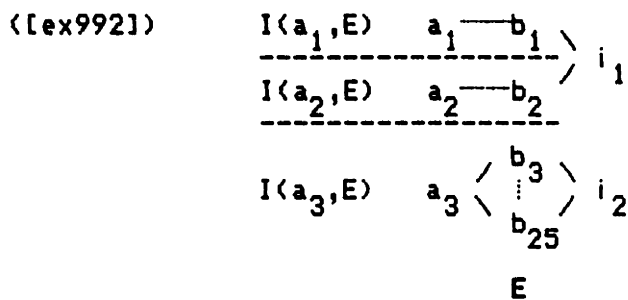
For (499) is true in a particular event or context of events E if and only if what the three agents did alone, $I\langle a_1, E \rangle$, $I\langle a_2, E \rangle$ and $I\langle a_3, E \rangle$, are each a selling of twenty-five buildings to two investors. As required, (499) is not true in (496):

and (314') will also be vacuous if the quantifier over sets is within the scope of a quantifier over individual objects, which, as in the example of (498), also determine a value for the event variable.

Now in any prefix containing quantifiers over individual objects, as in (ii), it is the rightmost quantifier over individual objects that determines the value of the event variable.

(ii) ...[Q N'(X_i)]...[Q(x_j,e):N'(x_j)]... \diamond [Q(x_n,e):N'(x_n)] R(...,e)

In interpreting the quantifiers with wider scope, the quantification over events will find that the event variable is not free in \diamond in (ii). [Although the event variable is not free in \diamond , the interpretation of the outer quantifiers over individual objects will still use the function I to restrict the context of events, as in (498).] The notational difference between quantifiers over individual objects and quantifiers over sets therefore has the effect that the rightmost quantifier over individual objects binds the event variable and elsewhere-- if there is no quantifier over individual objects-- the leftmost quantifier over sets binds it.



Note in particular that the set of twenty-five buildings, $\{a_1, \dots, a_{25}\}$, is not sold at any of the subevents $I(a_i, E)$, $1 \leq i \leq 3$.

Importing complex quantifiers over individual objects and the primitive semantic function " $I(x, E)$ " allows the relevant interpretation of (31) and (328) to be represented in set-denotative logic while assuming the Davidsonian decomposition of predicates in the lexicon.¹¹¹ But, we will now see that the complex quantifiers over individual objects and the primitive semantic function bring back the problems of secs. 6.2 and 6.3. Thus, any set-denotative logic with Davidsonian decomposition in the lexicon fails on (31) and (328), the first case of interpretations requiring an atomic predicate with both types of variables, or on the interpretations of secs. 6.2 and 6.3, the second case.

Recall that the Davidsonian decomposition in the lexicon provided a way out from the problems of secs. 6.2 and 6.3 by eliminating the expression of a true relations between sets and individual objects. The relation between sets and individuals, expressed by any atomic predicate according to the schema in (486), is just that of belonging to the same event. The complex

 111. Complex quantifiers over individual objects and the primitive semantic function would also allow clause (i.b) in the decomposition schema in (486) to be reformulated as (i.b') in n.105.

quantifiers over individual objects and the primitive semantic function " $I(x,E)$ " lose this way out because they restore the conditions of a true relation between sets and individual objects.

Suppose that an atomic predicate Φ has the variables over individual objects x_1, \dots, x_{j-1} and x_j and the variables over sets Y_k, \dots, Y_1 . (501) shows its truth conditions at $I(x_j, E)$. As in (486), Φ^* stands for the truth conditions of a true relation. The important point about these truth conditions is that if particular sets are the participants of a subevent $I(x_j, E)$, then whatever they did there must be related to x_j , since x_j is the only individual in its role in $I(x_j, E)$.

(501) " $\Phi(c_1, \dots, c_{j-1}, a, D_k, \dots, D_1, I(a, E))$ " is true iff

- (i) there exist sets c_1^+, \dots, c_{j-1}^+ such that $c_1 \in c_1^+$ and...and $c_{j-1} \in c_{j-1}^+$, and $\Phi^*(c_1^+, \dots, c_{j-1}^+, a, D_k, \dots, D_1)$ at $I(a, E)$, and
- (ii) there exist sets D_k^-, \dots, D_1^- such that $D_k^- \subseteq D_k$ and...and $D_1^- \subseteq D_1$, and $\Phi^*(c_1, \dots, c_{j-1}, a, D_k^-, \dots, D_1^-)$ at $I(a, E)$, and
- (iii) for all sets $S_1, \dots, S_j, T_k, \dots, T_1$,
if $\Phi^*(S_1, \dots, S_j, T_k, \dots, T_1)$ at $I(a, E)$, then $T_k \subseteq D_k$ and...and $T_1 \subseteq D_1$.

In sec. 6.2, the logical form in (382) represented interpretations of (357) that were unacceptably true in (358). The set-denotative logic with complex quantifiers over individual objects has (502) corresponding to (382):

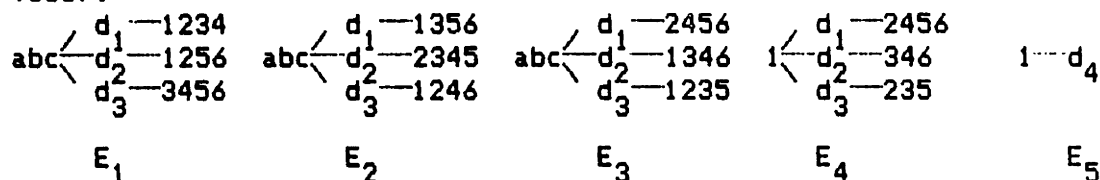
(357) No more than three billiard balls (ever) bounced off exactly three sides of the pool table.

(382) [No more than 3 balls($\langle X, i \rangle$)] [3! $\langle y, \text{side}(y) \rangle$] balls($\langle X, i \rangle$) bounced off side($\langle y \rangle$)

(502) [No more than 3 balls(X)] [3! $\langle y, e \rangle$: side($\langle y \rangle$)] balls(X) bounced(e) off side($\langle y \rangle$)

(503) "[3! $\langle x, e \rangle$: side($\langle x \rangle$)] $\Phi(x, e)$ " is true in E iff exactly three sides s are such that " $\Phi(s, I(s, E))$ " is true in $I(s, E)$.

(358):



The truth of (502) depends on those sets and events in (358) that satisfy

(504) (cf. (390)):

(504) balls(X) bounced(I(d₁,E₁)) off side(d₁) &
 balls(X) bounced(I(d₂,E₁)) off side(d₂) &
 balls(X) bounced(I(d₃,E₁)) off side(d₃)

None of the sets of balls in (358) satisfies (504). None has bounced off of each of the three sides of the pool table in any of the breaks. For example, the first break contains three subevents corresponding to what was done to each of the three sides of the pool table. The true atomic sentences about these subevents are only those in (505):

(505) balls({a,b,c,1,2,3,4}) bounced(I(d₁,E₁)) off side(d₁),
 balls({a,b,c,1,2,5,6}) bounced(I(d₂,E₁)) off side(d₂),
 balls({a,b,c,3,4,5,6}) bounced(I(d₃,E₁)) off side(d₃)

There is no one set satisfying all the conjuncts in (504). In particular, $C_{1-3} = \{a,b,c,1,2,3,4,5,6\}$ fails to. The billiard balls participating in any of the subevents are not C_{1-3} . With no sets to satisfy (504), (502) represents interpretations of (357) which are unacceptably true in (358). The outcome is the same as the one found in sec. 6.2 for the interpretations represented by (382). 112

112. Recall from the excursus in sec. 6.1.1 that (344) may misinterpret (341):

(341) Two boys danced with two girls.

(344) [2 girls(<Y,j>)] [2x:boy(x)] boy(x) danced with girls(<Y,j>)

When the atomic predicate expresses a true relation, we observed in sec. 6.3 that the logical forms in (439) represent interpretations that are false in the context of (421) and (429)¹¹³, although an interpretation of (420) is true there:

(420) Three automatic tellers gave (the) two new members exactly two passwords (each)

(439) a:

[3 atms($\langle X, i \rangle$)] [\langle the \rangle 2y: nw mmbr(y)] [2! z: psswr d(z)] atms($\langle X, i \rangle$) gave nw mmbr(y) psswr d(z)

(439) b:

[3 atms($\langle X, i \rangle$)] [\langle the \rangle 2y: nw mmbr(y)] [2! psswr ds($\langle Z, j \rangle$)] atms($\langle X, i \rangle$) gave nw mmbr(y) psswr ds($\langle Z, j \rangle$)

(344) required that each of two boys danced with the same group of two girls. Corresponding to (344), the logical form with a complex quantifier over individual objects may misinterpret (341) in the same way.

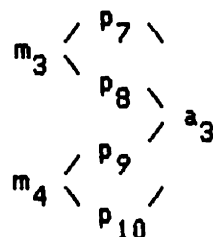
(506) [2 girls(Y)] [2(x,e): boy(x)] boy(x) danced(e) with girls(Y)

(507) "[2(x,e) boy(x)] Φ (x,e)" is true in E iff two boys b are such that " Φ (b, I(b,E))" is true in I(b,E).

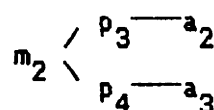
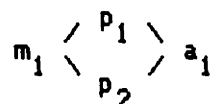
(506) requires that each of two boys be in a subevent in which he alone dances with girls and that some set of two girls be the participants danced with in all of these subevents. Thus, each of the boys danced with the same girls.

113. Recall that the event in (429) is added to the context just to falsify the irrelevant event-dependent interpretation of (420).

(429)



(421)



When the quantifiers over individual objects are complex, logical forms such as those in (508) and (509) will also represent interpretations that fail to be true in (421) and (429) despite the Davidsonian decomposition in (510) and (511).

(508) [3 atms(X)][the2(y,e):nw mmbr(y)][2!<z,e>:psswr(z)] atms(X) gave(e)
nw mmbr(y) psswr(z)

(509) [3 atms(X)][the2(y,e):nw mmbr(y)][2! psswrds(Z)] atms(X) gave(e)
nw mmbr(y) psswr(Z)

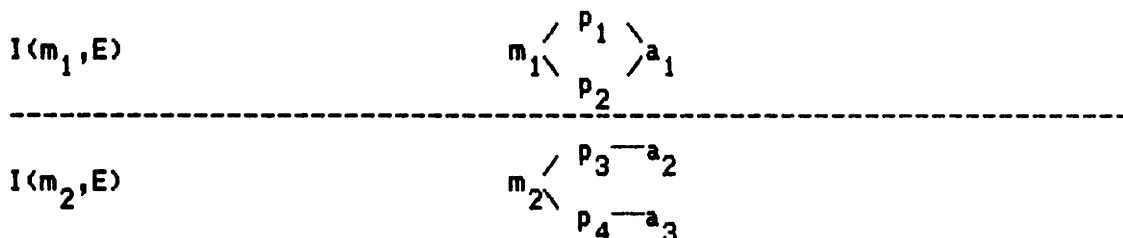
(510) "automatic tellers(A) give(i) new member(m) password(p)" is true iff
i. (relational str) automatic tellers A give new members passwords at i, and
automatic tellers give new member m password p at i, and
(event str) ii. for all sets X, Y and Z,
if automatic tellers X give new members Y passwords Z at i, then XCA.

(511) "automatic tellers(A) give(i) new member(m) passwords(P)" is true iff
i. (relational str) automatic tellers A give new members passwords at i, and
automatic tellers give new member m passwords at i, and
automatic tellers give new members passwords P at i, and
(event str) ii. for all sets X, Y and Z,
if automatic tellers X give new members Y passwords Z at i, then XCA and ZCP.

(512) "[the2(x,e):new member(x)]♦(x,e)" is true in E iff the two new members m are such that "♦(m, I(m,E))" is true in I(m,E).

(513) "[2!<x,e>:password(x)]♦(x,e)" is true in E iff exactly two passwords p are such that "♦(p, I(p,E))" is true in I(p,E).

(514)



(515)

$I(p_1, I(m_1, E)) = I(p_1, E)$	$\frac{\frac{p_1}{m_1} \quad a_1}{p_2} \quad I(p_2, I(m_1, E)) = I(p_2, E)$
$I(p_3, I(m_2, E)) = I(p_3, E)$	$\frac{\frac{p_3}{m_2} \quad a_2}{p_4} \quad I(p_4, I(m_2, E)) = I(p_4, E)$

(508) and (509) require there to be three automatic tellers among sets satisfying their respective formulas in (516) and (517):

(516) [the2(y,e):nw mabr(y)][2!(z,e):psswrd(z)] atms(X) gave(e) nw mabr(y) psswrd(z)

(517) [the2(y,e):nw mabr(y)][2! psswrds(Z)] atms(X) gave(e) nw mabr(y) psswrd(Z)

Given that the first quantifier in (517) is a complex quantifier over individual objects, a set satisfies this formula in (421) just in case it satisfies the conjunction in (518), where $I(m_1, E)$ and $I(m_2, E)$ are the subevents in (514):

(518) [2! psswrds(Z)] atms(X) gave($I(m_1, E)$) nw mabr(m_1) psswrd(Z) &
[2! psswrds(Z)] atms(X) gave($I(m_2, E)$) nw mabr(m_2) psswrd(Z)

Since, the automatic tellers participating in the two subevents are not the same, no set satisfies the conjunction in (518) and so no set satisfies (517). The logical form in (509), like (439b) represents interpretations of (420) that are false in (421) and (429).

Similarly, (507), like (439a), represents interpretations that are false in (421) and (429). Here the rightmost quantifier over individual objects "[2!(z,e):password(z)]" binds the event variable (see n. 110), and so a set in (421) that satisfies (516) must satisfy the conjunction in (519), where the subevents are those in (515):

for some sets C_1, \dots, C_k , the union of which is three automatic tellers, some events i_1, \dots, i_k in E , and some individuals d_1, \dots, d_k who are the two new members, " $\Phi(C_j, d_j, I(d_j, i_j))$ " is true in $I(d_j, i_j)$ for $1 \leq j \leq k$.

(522) " $[3 \text{ atms}(X)]X[\text{the2}(y, e): \text{nw mbr}(y)] \Phi(X, y, e)$ " is true in E iff for some sets C_1, \dots, C_k , the union of which is three automatic tellers, some event i in E , and some individuals d_1, \dots, d_k who are the two new members, " $\Phi(C_j, d_j, I(d_j, i))$ " is true in $I(d_j, i)$ for $1 \leq j \leq k$.

Retracing the argument, one finds that (523) and (524), like their corresponding logical forms in sec. 6.3.3.2, represent interpretations of (466) that are true in (467); but the interpretations they represent are also true, unacceptably, in (468) where only one new member is given exactly two passwords and the other is given four.

(466) Three automatic tellers gave the two new members exactly two passwords on a slip of pink paper.

Three automatic tellers gave the two new members on a slip of pink paper exactly two passwords each.

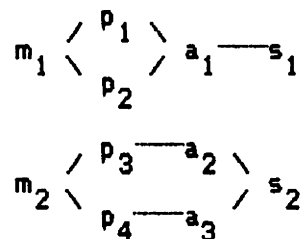
(523) (Cf. (471))

$[3 \text{ atms}(X)]X[\text{the2}(y, e): \text{nw mbr}(y)][2! \text{ psswrds}(Z)][E(w, e): \text{pnk slp}(w)]$
 $\text{atms}(X) \text{ gave}(e) \text{ nw mbr}(y) \text{ psswrds}(Z) \text{ on slp of pnk ppr}(w)$

(524) (Cf. (472))

$[3 \text{ atms}(X)]X[\text{the2}(y, e): \text{nw mbr}(y)][E(w, e): \text{pnk slp}(w)][2! \text{ psswrds}(Z)]$
 $\text{atms}(X) \text{ gave}(e) \text{ nw mbr}(y) \text{ psswrds}(Z) \text{ on slp of pnk ppr}(w)$

(467) (Cf. (421))



(468) (Cf. (432))

$$m_1 \begin{array}{c} / p_1 \backslash \\ \backslash p_2 / \end{array} a_1 \text{---} s_1$$

$$m_1 \begin{array}{c} / p_3 \text{---} a_2 \backslash \\ \backslash p_4 \text{---} a_3 / \end{array} s_2$$

$$m_2 \begin{array}{c} / p_5 \backslash \\ \backslash p_6 / \end{array} a_3 \text{---} s_3$$

As remarked earlier, the system that includes the complex quantifiers over individual objects and the primitive semantic function "I" essentially restores the truth conditions of a true relation between sets and individual objects, despite the Davidsonian decomposition in the lexicon. In the simple case of a relation with just one place for sets and one place for individual objects, " $\Phi(X, y, I(y, e))$ " is true if and only if the truth conditions of the true relation, $\Phi^*(X, y)$, obtain at e (see (501)). For this reason, the arguments of sec. 6.2 and 6.3, including the arguments against binary quantifiers in sec. 6.3.3.2, still hold of the set-denotative logic that combines Davidsonian decomposition in the lexicon with complex quantifiers over individual objects.

In this section, we have seen that the set-denotative logical syntax cannot be maintained by admitting in the lexicon a Davidsonian decomposition of polyadic predicates. Such a set-denotative logic will fail on one or the other of the cases (p.179) where an interpretation requires the atomic predicate to have both variables over sets and variables over individual objects.

6.5

In the preceding chapter, it was shown that the expressive power of set-denotative logics with events must be so restricted as to effectively eliminate quantification and predication over an independent domain of sets. The restrictions on set-denotative logics must recover the relationship among, sets, events and individuals found in event logic. Sec 5.1 showed that there are no proper relations between sets-- they are all functions on events. Sec. 5.2 showed that properties of sets, unlike properties of individuals, may not express a condition on the set's activity across events.

Finally, in this chapter, event logic and set-denotative logic have been distinguished by their syntax. Set-denotative logic, unlike event logic, requires any well-formed formula that contains "V" to contain a place for all the NPs in the (simple) sentence. For the set-denotative representations of the sum of plurals, the event-dependent and the non-event-dependent interpretations, a relevant event must satisfy a formula " $\Phi(\langle X, i \rangle)$ " in (315) below or " $\Phi(X, e)$ " in (316), which has a place X , bound by "[Q N']". In deriving these interpretations, event logic uses three factors such as those in (317), of which the third " $\Phi(e)$ " expresses the restriction on relevant events. It contains "V" the other NPs and their theta roles; but it does not contain a place or theta role bound by "[Q N']".

(315) [Q N'($\langle X, i \rangle$)] Φ [NP_j...NP_k V($\langle X, i \rangle$,...)]

(316) [Q N'] Φ [NP_j...NP_k V(X, e,...)]

(317) $[Q\ N'], \text{ INFL}(e, \alpha), \quad \Diamond [V(e) \ R_j(e, NP_j) \dots R_k(e, NP_k)]$

In sec. 6.2-6.4, we have compared the set-denotative formulas " \Diamond " in (318) and (319) with their counterpart in event logic, " \Diamond " in (320), where they contain quantifiers over individual objects.

(318) $\dots \Diamond [[Q'y:N'(y)] \dots V(X, i), y, \dots]$

(319) $\dots \Diamond [[Q'y:N'(y)] \dots V(X, e, y, \dots)], \text{ or}$

$\dots \Diamond [[Q'\langle y, e \rangle : N'(y)] \dots V(X, e, y, \dots)]$

(320) $\dots \Diamond [V(e) [Q'\langle y, e \rangle : N'(y)] \dots R(e, y) \dots]$

In the set-denotative logics, an event is relevant for interpretations based on (318) or (319) just in case it is an event in which some C has $V\dots$ -ed each of $[Q' \ N']$ -many individual objects. In event logic, an event relevant for interpretations based on (320) is one in which simply $[Q' \ N']$ -many individual objects have each been $V\dots$ -ed. It does not require that there be some C in the event to which the individual objects are all related. The occurrence of the variable X in " \Diamond " thus imposes an additional condition on relevant events. This additional condition resulted in the unacceptable interpretations of sec. 6.2 and 6.3.; moreover, there is no interpreting it away. If we weaken the meaning of " $X \ V\dots$ 'ed y at e " according to the Davidsonian decomposition in sec. 6.4, then set-denotative logic loses the power to express the first class of interpretations requiring both set variables and variables over individual objects: "the gerrymanderers (each) turned ten neighborhoods into eight electoral districts." This expressive power can be restored by redefining the quantifiers over individual objects so that the weakened conditions for " $X \ V\dots$ 'ed y at e " must obtain at each individual's subevent. But, we then again find the formula " \Diamond " with the

variable X imposing a condition on relevant events that results in the same unacceptable interpretations of sec. 6.2 and 6.3. It requires that a relevant event contain some C which is the participants in all of the [Q'N']-many individual objects' subevents.

We have seen in sec. 6.1-6.3 that the event logic-- which omits a place for X in the restriction on events-- consistently represents the correct interpretations. The set-denotative syntax fails because the atomic predicate "V" always appears with its full valence, including therefore a place for X.

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